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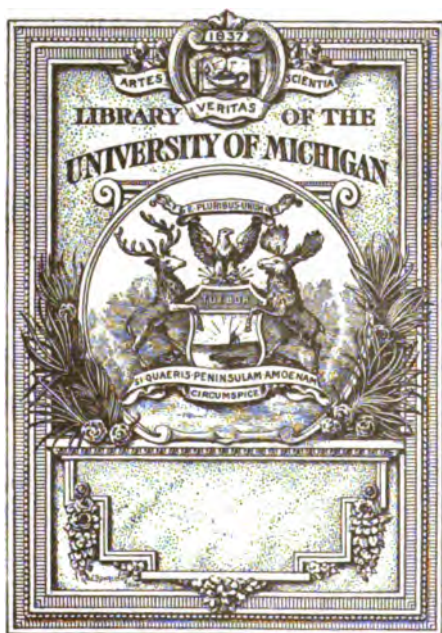
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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY—Bulletin No. 52, Part I.
D. E. SALMON, D. V. M., Chief of Bureau.

EXPERIMENTS CONCERNING TUBERCULOSIS,

UNDER THE SUPERVISION OF

THE BIOCHEMIC DIVISION.

PART I.

**The Virulence of Human and Bovine Tubercle Bacilli
for Guinea Pigs and Rabbits.**

BY

MARION DORSET, M. D.,
Assistant Chief of Biochemic Division, Bureau of Animal Industry.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1904.

LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., November 24, 1903.

SIR: I have the honor to transmit herewith a manuscript entitled "The virulence of human and bovine tubercle bacilli for guinea pigs and rabbits," by Dr. Marion Dorset, assistant chief of the Biochemic Division of this Bureau. This manuscript forms the first part of a bulletin on the general subject of "Experiments concerning tuberculosis," and I recommend therefore that this paper, with the two others to follow, be published as Bulletin No. 52 of this Bureau. The illustrations, consisting of two half-tone and three colored plates, are necessary to a clear exposition of the text of Part I.

Respectfully,

D. E. SALMON, *Chief.*

Hon. JAMES WILSON, *Secretary.*

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LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY, BIOCHEMIC DIVISION,
Washington, D. C., November 13, 1903.

SIR: I herewith submit for publication Part I of Bulletin No. 52 on
"Experiments concerning tuberculosis."

These experiments have been made for the purpose of studying the virulence of tuberculosis bacilli obtained from man and other animals. The work upon the large animals has been done by the Biochemic Division in conjunction with the Experiment Station of the Bureau. The studies with the small experimental animals and the general morphology have been made in the Biochemic Division.

Abstracts of the results of some of this work have been printed in various medical journals, but to secure the complete publication, with illustrations, it has seemed advisable to issue a bulletin in parts.

Part I refers to the comparative virulence of human and bovine tubercle bacilli for guinea pigs and rabbits, by Dr. M. Dorset.

Respectfully,

E. A. DE SCHWEINITZ,
Chief of Biochemic Division.

Dr. D. E. SALMON,
Chief of Bureau.

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EXPERIMENTS CONCERNING TUBERCULOSIS.

INTRODUCTION.

By E. A. DE SCHWEINITZ, PH. D., M. D.
Chief of Biochemic Division.

Though the difference in virulence of tuberculosis bacilli from various sources had been recognized for a long time, it was not until the publication of Koch's paper, which was read in London at the Tuberculosis Congress in 1901, that careful, systematic investigations in regard to the possibility of the transmissibility of bovine tuberculosis to man were extensively made. To determine this point positively it would be necessary to experiment upon man with bovine tuberculous material. As such experiments are not permissible, the other ways which have been followed in this study are the following:

(1) The comparative study of the virulence of human and bovine tubercle bacilli for small experimental animals.

(2) A study of the comparative virulence of human tubercle bacilli for pigs and cattle. These experiments include tests upon cattle with human tubercle bacilli obtained from the various organs and secretions of both adults and children.

(3) A study of the comparative virulence of tubercle bacilli of human and bovine origin for those animals most closely allied to man, namely, monkeys.

(4) A study of the morphological changes in both human and bovine tubercle bacilli produced by continued growth on various sorts of culture media, the influence of such media on the virulence or disease-producing power of these various bacilli, and the influence on the morphology and virulence of tubercle bacilli produced by their development in the animal body or upon various sorts of artificial media.

(5) A study of the cases of tuberculosis on record where the infection can apparently be traced to bovine tuberculous material.

(6) A chemical examination of the composition of tubercle bacilli obtained from various sources, and an examination of the different substances secreted and excreted by these bacilli grown upon artificial media.

(7) A comparison of the tuberculins made from cultures of tuberculosis of various animals.

(8) Experiments to immunize cattle against tuberculosis by previously inoculating these animals with attenuated human bacilli.

While a summary of the results of our own experiments and those of others along similar lines will be published in Part III of this bulletin, the following general conclusions drawn from our experiments may be given:

It is possible to obtain from cases of human tuberculosis germs which will produce tuberculosis in pigs, cattle, and monkeys upon subcutaneous inoculation. While it is possible by means of a number of different tests to draw fair conclusions as to the probable origin of these virulent tubercle bacilli, from a practical standpoint this is not of great importance. If we obtain from man a tuberculosis germ which will kill cattle on subcutaneous inoculation, and believe this germ to be originally of bovine origin, then it follows that bovine bacilli may infect man. If the tests show that the bacillus is of human origin, then the intertransmissibility of bovine and human tuberculosis is proved.

The genetic relation of tubercle bacilli of various origins has apparently been well established. While there is a great difference in virulence of various bacilli from different or similar sources, it is universally admitted that bovine bacilli are the most virulent for all species of animals upon which they have been tried; and the conclusions, apart from positive cases and experiments, that the bovine bacilli are virulent for other animals, including man, is perfectly natural and justifiable.

The experiments recorded in the several parts of this bulletin will substantiate the brief résumé given.

Part I.—THE VIRULENCE OF HUMAN AND BOVINE TUBERCLE BACILLI FOR GUINEA PIGS AND RABBITS.

By M. DORSET, M. D.,
Assistant Chief of Biochemic Division.

The experiments which are here recorded in Part I of this bulletin deal solely with the virulence of human and bovine tubercle bacilli for guinea pigs and rabbits, together with some observations upon the morphological and cultural characteristics of bacilli from both sources, the question of the intertransmissibility of human and bovine tuberculosis being only indirectly considered. The terms "bovine bacilli" and "human bacilli" are used in this paper to indicate the source from which the various organisms were originally obtained.

REVIEW OF THE LITERATURE.

The question as to the morphological and cultural identity of all mammalian tubercle bacilli was raised by Smith,^{1a} who also directed attention to the comparative differences in virulence of human and bovine tubercle bacilli for guinea pigs and rabbits.

In the researches just referred to, Smith carried out a most painstaking and exhaustive study of seven cultures from human sputum, six cultures from tuberculous cattle, one culture from a hog, one from a cat, and one from a case of tuberculosis in a horse. The cultures were all made on hardened dog's serum, from the organs of guinea pigs which had been inoculated with the sputum or with tissue from the above-mentioned animals. After a large number of comparative examinations, he formulates the following conclusions as to the morphology and cultural characteristics of human and bovine bacilli:

(1) Bovine and other animal bacilli (except *Nasua*, which is regarded as coming from man) grew less vigorously for a number of generations than the sputum bacilli. Sputum I is an exception and is probably an atypical form.

(2) Bovine bacilli are much less influenced by certain modifications of the culture medium.

(3) Bovine bacilli tend to remain short; human bacilli are either more slender from the start or become so during cultivation.

In testing the relative virulence of human and bovine tubercle bacilli for guinea pigs, Smith found that after intraperitoneal inoculation the

^aSuperior figures refer to the bibliography at the end of the article.

culosis in the course of 1 or 2 months. In this class were four human cultures and the two bovine cultures. The second class of cultures was of medium virulence, requiring a larger dose to produce a generalized tuberculosis, while the third class included those which even as the result of a large dose showed extensive changes in the lungs only, the disease not becoming generalized. The subcutaneous inoculations of rabbits showed human culture W and bovine culture I to be the most virulent of all, producing a generalized tuberculosis within a month.

The culture medium used seemed to have little influence upon the virulence of the various cultures, and twelve successive passages of a moderately virulent culture through a rabbit did not noticeably affect its virulence.

Very little difference in the character of the growths on culture media was observed by the author. The bovine cultures I and II and the above-mentioned virulent human culture W were remarkable on account of the strikingly short form of the individual bacilli, none of them exceeding 1.5μ in length. Especial attention is drawn to the fact that the cultures showing the shortest form in culture media were also the most virulent for rabbits. The author also states that those organisms possessing the greatest virulence for animals were isolated from especially malignant cases of tuberculosis in man.

Lartigau⁶ has reported briefly a series of experiments which were apparently similar to those of Vagedes, although the details were not given. He isolated nineteen cultures of the tuberculosis bacillus from a variety of human tuberculous lesions and found a wide variation in their virulence for rabbits and guinea pigs. One of his most virulent cultures grew very scantily and slowly, and on account of these properties and its morphological characters the author considers it as closely resembling the bovine bacillus. His other virulent cultures did not conform to this standard, however, as is shown by the following statement: "No relation could be observed between the morphology and virulence of the tubercle bacilli investigated."

Among other conclusions drawn from the work were the following: "Tubercle bacilli of great virulence were on the whole more difficult of cultivation, and the growths scantier and shorter lived than were tubercle bacilli of less virulence. Tubercle bacilli of widely different virulence may be present in any one of the various human tuberculosis lesions."

Lartigau also says that tubercle bacilli of feeble virulence are to be expected in those cases of pulmonary tuberculosis where the disease is progressing very slowly, thus agreeing with Vagedes, as noted above.

In some recently published experiments Veszprémi⁷ records the following results:

By the intravenous injection of various human tubercle bacilli into

rabbits it was possible to separate the cultures into several classes, the separation being based upon their virulence. Bacilli of very weak virulence produced a considerable number of tubercles; these did not become caseous, but usually showed retrogressive changes. Bacilli of medium virulence produced a large number of tubercles, but no evidence of a toxic effect was noted. Bacilli of great virulence produced tubercles in which the bacilli multiplied and brought about marked and widespread caseation, and they furthermore exhibited a strongly toxic action. They also appeared to possess the power of disseminating themselves rapidly and overwhelming the animal. The author found by comparing the clinical history of the cases from which his cultures were isolated with the results which he obtained by the inoculation of rabbits that the most virulent cultures came from those cases which were either of recent origin or which had run a rapid course. Owing to the comparatively small number of cultures which he isolated, he was not able to form positive conclusions, but his experiments may be considered as evidence indicating that it is from the most rapidly fatal cases of tuberculosis that we may expect to derive the most virulent cultures of the tubercle bacilli. In these conclusions he agrees with Vagedes and Lartigau.

Krompecher & Zimmermann⁴ record the results of their investigations concerning the virulence of thirty cultures of the tubercle bacillus derived from as many cases of surgical tuberculosis in human beings. These authors lay great stress upon the fact that all of their cultures were made upon glycerinized potato directly from the human tissues, and they are of the opinion that all systematic studies of the comparative virulence of tubercle bacilli found in various cases of human tuberculosis are unreliable if the virus has been passed through an animal previous to making the pure cultures, and such bacilli, in their opinion, should be classed as animal and not human bacilli. Without going into an extended discussion of this question, it is believed that such an assumption on the part of Krompecher & Zimmermann is unjustifiable in the light of my own experiments and those of other observers. Smith¹ obtained all of his cultures by a preliminary passage through a guinea pig, and he records no increase in the virulence of the feebler cultures and no decrease in that of the more potent ones. Vagedes⁵ records the successive passage of a culture of medium virulence through twelve rabbits without any noticeable change in its virulence. I have also had occasion to pass a human culture of moderate virulence and a bovine culture each successively through six rabbits without any apparent modification of their virulence.

Krompecher & Zimmermann also express the opinion that all tubercle bacilli from cases of surgical tuberculosis and a part at least of those from pulmonary tuberculosis are of about equal virulence, and they intimate that those cultures from pulmonary cases which possess an exalted virulence may owe their greater power to a mixed infec-

tion. The different course of the various tuberculous diseases is, in their opinion, due rather to a difference in the disposition of the various tissues and organs than to differences in virulence between the infecting bacilli. In regard to this latter statement, I am of the opinion that both the virulence of the bacilli and the individual susceptibility of the infected persons must be taken into account in explaining the variations in the course of different cases of tuberculosis.

Strauss⁹ mentions the very considerable resistance shown by rabbits to tuberculosis, and calls attention to the fact that, although the spleen and liver may present tuberculous lesions after subcutaneous inoculation, they are not pronounced, the lungs and kidneys being the organs which are most extensively diseased. He probably refers to human tuberculous virus, although the source of his culture and the details of work are not given.

Prudden & Hodenpyl¹⁰ were the first to describe the effect produced upon rabbits by the intravenous injection of dead tubercle bacilli. They do not state the source of their cultures, though it was presumably human. The chief lesions produced by their inoculations were many small nodules in the lungs and liver—a few in the spleen. These lesions showed no tendency whatever to a cheesy degeneration, and the longer the animal was allowed to live the fewer were the tubercle bacilli that could be found in the lesions. Later investigators have shown¹¹ that a certain amount of caseation may result from the injection of dead tubercle bacilli, although such a process must necessarily be limited, as the bacilli can not multiply.

A brief summary of the literature just quoted shows that Smith found all of his bovine cultures more virulent for guinea pigs and rabbits than his human cultures; Ravenel finds the same, with two exceptions: One bovine culture after short cultivation approached the human type and one human culture, virulent for calves upon intravenous inoculation, corresponded more nearly to the bovine than the human type in its morphological and cultural features. Its virulence for rabbits and guinea pigs was not reported. The work of Vagedes and Lartigau shows that there may be a wide variation in the virulence and morphology of tubercle bacilli of human origin, and the former describes a human bacillus which was equal in pathogenic power to bovine cultures which he also had under cultivation.

It can be seen that, although Smith in his first report noted differences which were most marked between human and bovine bacilli in their effect upon guinea pigs and especially rabbits, no attempt has been made to confirm his results except by Ravenel.

It was, therefore, with the idea that the inoculation of rabbits might perhaps prove to be an easy and simple method of distinguishing between human and bovine tubercle bacilli that the experiments now to be described were undertaken. It is a well-known fact that

tubercle bacilli are very tenacious of their virulence, and if it can be shown that all tuberculous virus of bovine origin possesses an exalted virulence for rabbits, as is indicated by Smith's work, and that all tubercle bacilli from cases of human tuberculosis are lacking in this property, the rabbit test would be a most efficient aid in determining the source of the contagion in those cases of human disease where there is reason to suspect infection from bovine sources.

I have followed as closely as possible the methods detailed by Smith¹ in the *Journal of Experimental Medicine*, except in the matter of a culture medium, as will be explained later.

THE EXPERIMENTS IN DETAIL.

THE CULTURE MEDIUM.

For the isolation and propagation of all cultures, a medium consisting of the mixed white and yolk of hen's eggs was used. This medium has been previously described,¹² but owing to the fact that some slight changes have been made in the method of preparation, it seems best to review the process as it is now carried out.

The egg shell is broken carefully and the entire contents dropped into a wide-mouthed sterile flask. The yolk may be broken with a sterile platinum wire. The flask should be shaken until the white and yolk are thoroughly mixed, and 25 c. c. of distilled water added to every four eggs. The mixture is then strained through a sterile cloth. This procedure serves to remove the foam produced by shaking, and in addition furnishes a homogeneous medium which will not otherwise be obtained. The egg is now poured into sterile tubes, care being taken to avoid foaming, and the tubes, each containing about 10 c. c. of the medium, are inclined in a blood serum oven and hardened at a temperature of 73° to 76° C. This hardening usually covers 3 days—4 or 5 hours each day. During the first 2 days the temperature is maintained at 73° C., and on the last day it is carried to 76° C. This prolonged intermittent heating, in addition to producing a firm medium, almost always accomplishes a perfect sterilization. A small dish of water is kept in the oven during the entire time of heating in order to prevent drying. After sterilization and hardening have been completed we have a firm, opaque, yellowish medium, which usually contains very little water of condensation. Since moisture, as shown by Smith, is very necessary to a satisfactory development of the tubercle bacillus, it is often advisable to add a few drops of sterile distilled water to the egg tubes just before inoculation. If the water be added before hardening the surface of the medium is apt to be too soft.

In making cultures from tissues, a small piece of the material is well mashed with a pair of forceps, transferred with a platinum wire to the

DESCRIPTION OF PLATE I.

FIG. 1.—Twenty-eight days' culture of human tubercle bacillus, F T, on solidified dog's serum, fifth generation. Preparation stained with cold carbol-fuchsin and decolorized with 10 per cent sulphuric acid as described in text. Magnified 1,200 diameters. Photograph by James A. Emery.

FIG. 2.—Twenty-eight days' culture of bovine tubercle bacillus, C No. 81, on solidified dog's serum, fifth generation. Preparation stained with cold carbol-fuchsin and decolorized with 10 per cent sulphuric acid as described in text. Magnified 1,200 diameters. Photograph by James A. Emery.

DESCRIPTION OF PLATE II.

FIG. 1.—Twenty-eight days' culture of human tubercle bacillus, C No. 4, on solidified dog's serum, fifth generation. Preparation stained with cold carbol-fuchsin and decolorized with 10 per cent sulphuric acid as described in text. Magnified 1,200 diameters. Photograph by James A. Emery.

FIG. 2.—Twenty-eight days' culture of human tubercle bacillus, S E No. 3, on solidified dog's serum, fifth generation. Preparation stained with cold carbol-fuchsin and decolorized with 10 per cent sulphuric acid as described in text. Magnified 1,200 diameters. Photograph by James A. Emery.



Fig. 1.



Fig. 2.

TUBERCULOSIS BACILLI, GROWN ON DOG'S SERUM.

Fig. 1, human bacilli; fig. 2, bovine bacilli.



Fig.1.



Fig.2.

TUBERCULOSIS BACILLI, GROWN ON DOG'S SERUM

Figs. 1 and 2, human bacilli.

(8) *Culture F T, human*.—Obtained from the spleen of a guinea pig which was inoculated with a small fragment of a mesenteric gland from a 12-year-old girl who had died of an intestinal and peritoneal tuberculosis.

(9) *Culture C No. 4, human*.—Obtained from the spleen of a guinea pig which was inoculated with a small fragment of a peritoneal tubercle from a child of 5 years that had died of a generalized tuberculosis.

(10) *Culture No. 50, human*.—Obtained from the spleen of a guinea pig which had been inoculated with a bit of spleen from a tuberculous baboon. The baboon was inoculated with a human culture which had been under cultivation in this laboratory for a long time, a history of the culture not being available.

(11) *Culture C No. 81, bovine*.—Obtained from the spleen of a guinea pig which had been inoculated with a fragment of a mediastinal gland from a cow suffering from tuberculosis; natural infection.

(12) *Culture III, bovine*.—Obtained from the spleen of a guinea pig which had been inoculated with a small fragment of the lung of a tuberculous baboon. The baboon had been inoculated with a small amount of bovine III (Smith) tubercle culture. This culture had previously been grown for some time on bouillon in addition to having been cultivated on blood serum for a number of generations before reaching our hands.

It can be seen from the above record that a considerable variety of human cultures was used, all, with one exception, being recently isolated. Only one freshly isolated bovine culture was used. That culture, however, was fully equal in virulence to any of the bovine cultures described by Smith, and was considered entirely satisfactory as a standard with which to compare the human cultures.

CULTURAL CHARACTERS.

Macroscopic appearance of cultures.—All examinations as to the morphological and cultural peculiarities were made upon cultures which were of the same age and which had been grown, under identical conditions, upon the same lot of culture media.

Egg cultures.—In examining cultures upon the egg medium one feature of the growths was quite constant in the case of all the different strains of tubercle bacilli. This was the appearance of small, round, distinct colonies over the inoculated surface, the number of such colonies depending, of course, upon the number of bacilli in the tissue which is introduced. Transfers from one tube to another never exhibited the colony formation, owing to the relatively large number of organisms introduced.

A close examination of the gross characters of the various cultures, both originals and subcultures, made it possible to separate them into two groups. These differences were slight, and it must be borne in

mind that a more prolonged cultivation may entirely obliterate the dividing line.

Group I (consisting of cultures E T and C No. 4, human; C 81, and III, bovine) was characterized by the very scanty growth, by the fact that the colonies in cultures from guinea pigs were quite small and flat and tended to coalesce, and by the physical condition of the growth, which was moist and glistening in fresh cultures. A portion of the growth could be easily removed with a platinum loop and brought into a state of fine subdivision in bouillon.

Group II (consisting of human cultures F T, F L, S E No. 3, G. D, 12124, C No. 1, D T, and No. 50) exhibited usually in original cultures, round distinctly elevated colonies, and in subcultures the growth was more abundant than in the cultures of Group I. It was dry, rather difficult to remove with a platinum wire, and not infrequently exhibited a sheen on the surface. The growths of this group on egg were brought into a fine state of subdivision with considerable difficulty, it being practically impossible to get rid of the many small flakes which clung together and could not be broken up. Smith noted, in regard to serum cultures of his bovine and human organisms, that the bovine cultures could be brought into a finer state of subdivision than the human cultures.

Serum cultures.—During the length of time they have grown on serum (about 5 months), the distinction between the two groups has not been so marked as could be noted in the case of egg cultures. In fact, the differences between the two sets of cultures were not sharply defined, there being really more differences between the individuals of each than were found between the groups as a whole. In the case of Group I in C No. 81, E T, and bovine III, the gross appearances agreed fairly well, although there were differences noted in the several transfers which were mainly attributable to variations in the amount of growth. Culture C No. 4, grew very poorly on the serum, almost always presenting simply a thin film of growth, giving a ground-glass appearance to the culture. In Group II several of the members grew in a manner practically indistinguishable from the bovine cultures, while culture D T gave from the beginning a heavy abundant white growth.

To sum up the gross differences observed in cultures upon hardened dog's serum, they seem to depend upon the luxuriance of the growth rather than upon any qualitative variation, with the exception of culture C No. 4, in which instance it was evidently of a different character. It is quite manifest that in the case of two growths, both in themselves white, the one which is the most abundant will be opaque and will therefore present a white color, whereas the other, growing less vigorously and forming a film which is translucent, will appear to be gray. The varying color of the cultures upon serum, therefore, seems to be due wholly to the amount of growth which takes place.

The serum was hardened at 74° to 76° C., and identical lots of serum were used for all comparative examinations. The cotton plugs were paraffined, as in the case of the egg cultures.

Microscopic appearance of the cultures.—The method of making the preparations for microscopic examination was as follows: A small portion of the culture to be examined was spread in a thin film on a cover-slip and allowed to dry in the air. The preparation was then fixed in a hot-air oven at a temperature of 112° to 117° C. for 40 minutes. It was stained with cold carbol-fuchsin for 30 minutes and, after rinsing in distilled water, the preparation was allowed to remain 30 seconds in 10 per cent sulphuric acid (by volume); then it was thoroughly rinsed with water, dried, and mounted in Canada balsam. This method was followed in all comparative examinations, and, in addition, in order to insure identically the same treatment, all of the preparations to be examined were fixed together in the same oven for the same length of time.

Microscopic examination of egg cultures.—The comparative examinations of cultures on egg have failed to bring out any marked differences in the morphology of the various strains of tubercle bacilli, although it is quite possible that certain differences which I have found to be very slight now might, after a prolonged period of cultivation on this medium, become more marked. Generally speaking, all of the individuals from all of the cultures were well stained, short, and rather thick. Very little tendency to beading was noticed in any of them, and they were all quite uniform in size, long and short forms not being seen together in any of the preparations. The usual length of the individual organisms was 1.5 to $2\ \mu$. D T, human, and C No. 1, human, might be put down as exceptions, for they have usually been from 2 to $2.5\ \mu$ in length, but with no visible tendency to lengthen during cultivation.

Microscopic examination of serum cultures.—The cultures C No. 81, bovine, E T, human, and C No. 4, human, have been grown also on dog's serum. It has already been shown that these three cultures were practically identical in the gross appearance of their growths on egg, and, as will appear later, they corresponded so closely in other properties that it was thought advisable to study carefully their characters when grown on hardened dog's serum. Their cultivation upon this medium has now extended over a period of about 5 months. During this time cover-glass preparations have been made several times exactly according to the method described for the egg cultures. Cultures C No. 81, bovine, and E T, human, are now, after 5 months of cultivation, morphologically indistinguishable. Both organisms are short and thick, 1.5 to $2\ \mu$ long, generally straight, and uniformly stained. In culture C No. 4 the individuals are perceptibly longer and slenderer and are usually stained evenly, though in some of the cultures beading has been quite prominent. The length of these organisms is from 2 to

2.5 μ . The differences pointed out have existed since the first generation on dog's serum and have not increased during cultivation through five successive generations. The accompanying photographs (Pls. I and II, p. 10) illustrate fairly well the morphological characters of cultures C No. 81, E T, C No. 4, and S E No. 3 when grown on hardened dog's serum.

The following summary of results will serve to bring together the salient features of the growth of the various cultures on egg and blood serum:

(1) The gross characters of the various cultures on egg were of such a nature that they could be separated into two groups. Group I comprised the most virulent cultures, as is shown later in this paper, and the differences between the two groups were sufficiently marked to make it possible to predict that certain cultures (on account of their resemblance to the bovine cultures on egg) would prove virulent for calves, which prediction was borne out by the results of subsequent inoculation experiments. Group I includes two bovine cultures and two human cultures. Group II includes the remaining human cultures.

(2) The microscopic characters of the various organisms cultivated on egg exhibited such slight differences that no sharp division line could be drawn. The bovine bacilli were indistinguishable from the majority of the human bacilli.

(3) The gross characters of the cultures on dog's serum did not permit of a division into two groups such as was possible with the egg cultures, the differences which were observed being in the quantity of growth rather than in its quality. There was one exception to this rule and that was in culture C No. 4, human, which always exhibited a thin film, resembling ground glass, never growing so luxuriantly as the others.

(4) The microscopic characters of the three cultures which were grown on dog's serum long enough to make a careful examination of them worth while; that is, cultures E T, C No. 4, human, and C No. 81, bovine, were not such as to permit of any sharp distinction between them, though culture C No. 4, was slightly longer from the first than the other two.

PATHOGENIC PROPERTIES.

GUINEA PIGS.—All of the animals which were used in these experiments were as vigorous and healthy as it was possible to obtain them. None had ever been used for any other purpose; and, after inoculation, they were kept in perfectly clean, separate cages, one guinea pig usually being placed in a cage with a rabbit which had received the same culture. The animals were not handled after inoculation, the main reliance being placed upon the length of life and the result of the macroscopic and microscopic examinations after death. The heaviest guinea pig weighed 664 grams and the lightest 424 grams, the

average weight being 532 grams. All guinea pigs were inoculated subcutaneously on the inner side of the thigh. The doses given were as nearly uniform as it was possible to make them, the culture being prepared for inoculation in the same manner as that used by Smith, which is as follows: Particles of the culture were carefully transferred from the culture tube to the inside of a dry sterile test tube until sufficient was obtained to make the desired amount of suspension. By the use of a heavy platinum wire having a flattened spatula-like end, the clumps of bacilli were rubbed against the sides of the tubes until all were broken up and the bacilli smeared in a thin film on the glass. A small amount of sterile peptonized bouillon was now added and by means of the platinum wire the culture was mixed thoroughly with the fluid. More bouillon was added until the required dilution was obtained. For reasons previously stated, I have adopted for all inoculations a suspension which was made as nearly as possible equal in density to a 24-hours typhoid culture. A uniform dose of 0.5 c.c. was used.

The guinea pig which survived the longest was one which received human culture No. 50, the animal dying of generalized tuberculosis 61 days after inoculation. This culture, previous to its passage through the monkey, had been grown on artificial media for more than 8 years. One guinea pig inoculated with human culture C No. 1 lived 54 days, although another guinea pig of greater weight than the first one succumbed to an equal dose of the same organism in 31 days. The other animals died after inoculation at varying lengths of time ranging from 40 days downwards.

In Table I a summary of the inoculations and their results is given. For the sake of obtaining a better comparison in the discussion of these results, the various cultures have been divided into three groups. It must be understood, however, that this grouping is made in order that the results may be more clearly explained and not primarily on account of their different effect upon guinea pigs.

A few of the guinea pigs died within less than 2 weeks after inoculation, and unless these animals showed sufficient tuberculosis to account for their death they were not taken into consideration in computing the average length of life. Such animals are marked with a star in the tables.

Group I, bovine cultures C No. 81 and III.—The guinea pigs inoculated with these cultures had an average weight of 542 grams and lived after inoculation an average of $23\frac{1}{2}$ days.

Group II, human cultures E T and C No. 4.—The guinea pigs inoculated with these cultures had an average weight of 565 grams and lived an average of $22\frac{1}{4}$ days.

Group III, human cultures, No. 50, F L, S E No. 3, G D, 12124, C No. 1, and D T.—The guinea pigs inoculated with this group of

cultures had an average weight of 530 grams and lived an average of 35½ days.

It will be seen that between Group I (bovine cultures C No. 81 and III) and Group II (human cultures E T and C No. 4) the differences in the length of life after inoculation are so slight that no separation based on this point would be possible. If anything, the human cultures C No. 4 and E T might be considered as slightly more virulent; for, although the guinea pigs of this group averaged 23 grams heavier, they lived an average of 1 day less.

The cultures of Group III are apparently distinctly less virulent for guinea pigs than those of Groups I and II, the animals having survived an average of 12 days longer than the bovine guinea pigs, which were of greater average weight.

The similarities and differences between these three groups appear also in the results of the postmortem macroscopic and microscopic examinations. The spleen, liver, and lungs are the organs which are principally affected in guinea pigs, and when the inoculation has been made subcutaneously on the inside of the thigh the lungs are the last of those organs to exhibit signs of the disease. For this reason the time required for the lungs to become involved may be taken as an index of the rate of progress of the disease, and I have considered the tuberculosis as generalized only when the lungs as well as the liver and spleen are affected.

In the case of the animals inoculated with cultures of Group III, the disease was generalized in all of those which survived 31 days or more. In those which survived longest the characteristic yellowish areas in the liver and the tubercles in the lungs were largest and most numerous, and the spleen was also most extensively diseased. In the case of those animals inoculated with the cultures of the Groups I and II the disease was generalized in all those which survived more than 23 days. None of the animals inoculated with these cultures lived more than 28 days, and only in those which survived the inoculation the longest were the large, yellowish, bile-stained areas in the liver very prominent. That organ, while showing in those which died first some such changes, had usually the appearance of having undergone very rapid degenerative changes, which, while just as extensive, had not developed so far as in those animals of Group III which lived for a longer time.

The impression conveyed, therefore, by the macroscopic appearance at the autopsies on guinea pigs was that the disease induced by the cultures of Groups I and II was more rapid in its progress than that induced by the cultures of Group III, and that death resulted from the extensive interference with the functions of the various organs before the tuberculous process had really reached its height. In the case of Group III the disease seems to have been disseminated less rapidly, the organs being able to perform their functions less perfectly, of

DESCRIPTION OF PLATE III.

FIG. 1.—Section of lung of guinea pig No. 2077. Animal was inoculated with bovine tubercle culture C No. 81. Tissue hardened in alcohol and embedded in celloidin. Stained with hematoxylin and carbol-fuchsin as described in text. Drawn with camera lucida. Magnified 1,450 diameters.

FIG. 2.—Liver of guinea pig No. 2077. Same as fig. 1.

FIG. 3.—Section of lung of guinea pig No. 2592. Animal was inoculated with human tubercle culture C No. 4. Tissue hardened in alcohol and embedded in celloidin. Stained with hematoxylin and carbol-fuchsin. Drawn with camera lucida. Magnified 1,450 diameters.

FIG. 4.—Liver of guinea pig No. 2592. Same as fig. 3. Drawings by W. S. D. Haines.

DESCRIPTION OF PLATE IV.

FIG. 1.—Section of lung of rabbit No. 538. Animal was inoculated with bovine tubercle culture C No. 81. Tissue hardened in alcohol and embedded in celloidin. Stained with hematoxylin and carbol-fuchsin. Drawn with camera lucida. Magnified 1,450 diameters.

FIG. 2.—Liver of rabbit No. 538. Same as fig. 1. Drawings by W. S. D. Haines.

DESCRIPTION OF PLATE V.

FIG. 1.—Section of lung of rabbit No. 488. Animal was inoculated with human tubercle culture C No. 4. Tissue hardened in alcohol and embedded in celloidin. Stained with hematoxylin and carbol-fuchsin. Drawn with camera lucida. Magnified 1,450 diameters.

FIG. 2.—Liver of rabbit No. 488. Same as fig. 1. Drawings by W. S. D. Haines.



Fig. 1.



Fig. 2.

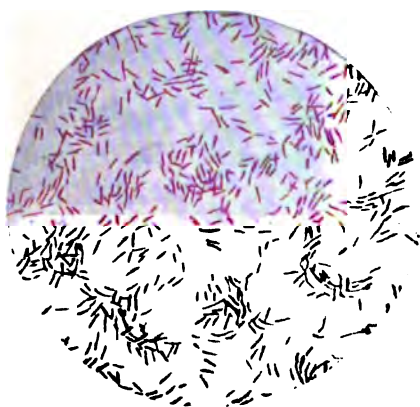


Fig. 3.



Fig. 4.

Sections showing bacilli in tubercles from inoculated guinea pigs.
Figs. 1 and 2, bovine, Figs. 3 and 4, human tuberculosis.

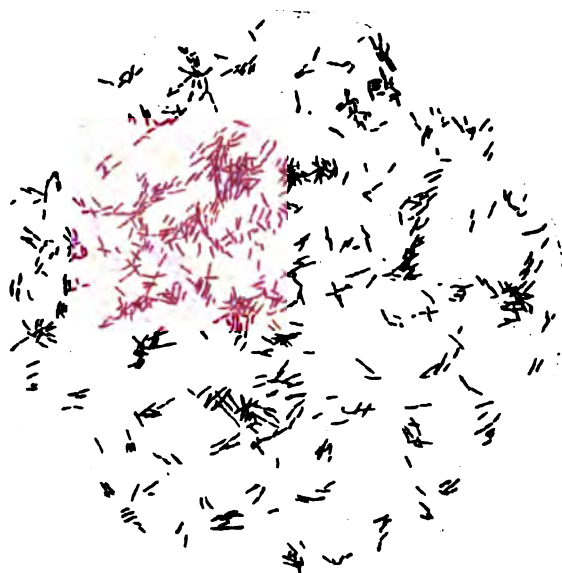


Fig. 1.



Fig 2.

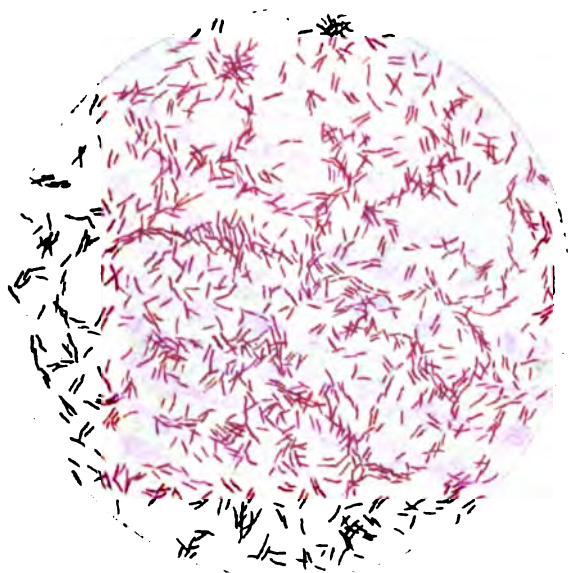


Fig. 1.



Fig. 2.

course, but sufficiently long for the tubercles to reach a further stage of development.

The microscopic examination of the tissues from the various animals was made as complete as possible, sections being made of the spleen and liver, and of the lungs also whenever any disease of those organs was present. The methods used for preparing the tissues and staining were as follows: The hardening was done with 80 per cent alcohol and the tissues embedded in celloidin. For the examination of tissue changes the sections were stained with Delafield's hematoxylin and with eosin, and mounted in Canada balsam after clearing with creosote. For the demonstration of tubercle bacilli the sections were usually stained lightly with hematoxylin and 30 minutes in cold carbol-fuchsin. The removal of the excess of carbol-fuchsin was effected by means of Orth's discharging fluid,^a the section being subsequently immersed in water containing a trace of ammonia to restore the blue to the cell nuclei. In some instances the hematoxylin was not used, the counterstaining being accomplished by means of methylene blue after the use of the carbol-fuchsin. All the sections were cleared in creosote or clove oil and mounted in Canada balsam.

In the microscopic examination of the tissues, special attention was paid to the following points: 1, the number and size of the tubercles; 2, the condition of the tubercles—whether they showed necrosis of the center and whether there were any evidences of retrogressive changes indicating decided resistance on the part of the body to the invasion of the tubercle bacillus; 3, the number of tubercle bacilli in the lesions.

First of all it may be stated that, in the microscopic as in the macroscopic examinations, no essential difference in the nature of the pathologic changes could be noted in the different guinea pigs. The differences observed were only such as are always found in tubercles which have reached varying stages in their development. The histologic changes in the organs of animals inoculated with cultures of Groups I and II were practically identical in those animals which survived approximately the same length of time, while in those animals inoculated with Group III which died at the end of the same number of days the lesions were always less advanced, about 8 days longer being required for cultures of this group to produce lesions approximating those produced by Groups I and II.

In none of the guinea pigs were the lung tubercles sufficiently far advanced to show a characteristic necrosis of the central portion, although in a few instances its beginning was indicated by a fragmentation of the cell nuclei. The liver and spleen in all the inoculated guinea pigs contained tubercles with characteristic central necrosis and usually in the liver the hepatic cells outside of the zone of the tubercles showed greater or less degenerative changes, indicated by

^aHydrochloric acid, 1 c. c.; 70 per cent alcohol, 99 c. c.

obliteration of the nuclei and a fatty degeneration. In the spleen the tubercles were not well defined, there being found, as a rule, large irregular areas of coagulation necrosis. Tubercle bacilli were most abundant in these necrotic areas.

Tubercle bacilli were much more abundant in the tubercles in those guinea pigs inoculated with the cultures of Groups I and II than in those inoculated with any of the members of Group III. There were no constant differences between the bovine cultures C No. 81 and III, on the one hand, and the human cultures C No. 4 and E T, on the other. In the sections tubercles would occasionally be found after inoculation with the bovine cultures which contained more tubercle bacilli than certain tubercles in guinea pigs inoculated with C No. 4 and E T, and the exact reverse was occasionally noted. Such differences, however, were not marked, and no distinction, based on the number of bacilli in the tubercles, could be made between bovine cultures C No. 81 and III, on the one hand, and human cultures C No. 4 and E T, on the other. The accompanying drawings (Pl. III) illustrate very well the number of tubercle bacilli in the central portion of tubercles after inoculation of guinea pigs with bovine culture C No. 81 and the most virulent human cultures.

As a result of the guinea-pig inoculations just described, the following conclusions may be formulated, although they are based upon such slight differences that the distinctive features might be entirely obliterated by a series of experiments in which the animals used were appreciably lighter or where the dose of culture was appreciably greater:

- (1) There was a sufficient variation in the virulence of the human cultures for guinea pigs to permit of their provisional separation into two groups.

- (2) In those animals inoculated with the most virulent group of human cultures the disease was marked by its rapid progress (death in less than 30 days) and by the relatively greater number of tubercle bacilli in the lesions.

- (3) There were no differences observed in the effect produced by the two most virulent human cultures and the two bovine cultures on guinea pigs. In both the disease was rapid in progress and in both tubercle bacilli were very numerous in the lesions.

- (4) As a general proposition it may be stated that in the case of guinea pigs weighing over 400 grams and inoculated subcutaneously with 0.5 c. c. of a suspension having a density of a 24-hours typhoid culture a difference of from 100 to 150 grams in weight did not appear to influence the length of life of the animals.

RABBITS.—Aside from their effect upon cattle, it is upon their virulence for rabbits that Smith has laid particular stress in defining the differences between human and bovine tubercle bacilli, and in the inoculation experiments herein recorded every endeavor has been made

to follow his methods closely, the only differences being in the culture medium used (egg instead of blood serum) and in the fact that, instead of favoring the human cultures by using lighter animals for them, I have endeavored to use rabbits for the human cultures which were equally as heavy or heavier than those which were inoculated with the bovine cultures. A glance at Table II will show that in all cases where duplicate inoculations were made the animals inoculated with the human cultures had a greater average weight than those inoculated with the bovine cultures.

The cultures were prepared for inoculation in the same manner as for the guinea-pig experiments. A uniform dose of 0.5 c. c. was used and all inoculations were made into an ear vein. No rabbits weighing less than 1,350 grams were used, and after inoculation they were not disturbed—no attempt being made to take temperatures or to weigh the animals.

An examination of the table will show that the various cultures may be readily separated into two groups, the separation being based upon the length of life and the gross lesions observed at the autopsy. The cultures of Group I, consisting of bovine cultures C No. 81 and III and human cultures C No. 4 and E T, caused the death of all rabbits within 20 days, the autopsy revealing always a severe generalized tuberculosis. The rabbits inoculated with the cultures of Group II, on the contrary, lived an average of 105½ days (one animal inoculated with culture C No. 1 is still living at the end of a year). Five rabbits of this group died within 48 days after inoculation, 2 of this number succumbing on the twenty-seventh day. The rabbits of this group which succumbed before the forty-eighth day presented a very much less severe tuberculosis, however, than those inoculated with Group I. The gross lesions observed in the rabbits inoculated with the cultures of Group I presented at death a typical picture of a severe rapidly progressive miliary tuberculosis. The lungs were literally filled with minute tubercles 1 mm. or less in diameter, most of which showed a distinctly white necrotic center. The lungs did not collapse when the chest cavity was opened, the disease being so extensive that the lobes were almost completely solidified. The liver was rather large, and minute grayish points could usually be seen scattered over its surface. The spleens of all the animals were much enlarged, being usually from two to four times the normal size, and having scattered over their surfaces minute grayish areas, which were frequently so numerous as to give a steel-gray color to the organ, which, owing to the congestion, would otherwise have been dark red. The kidneys frequently showed on their surface numerous small grayish points quite similar to those seen on the liver and spleen.

The severe involvement of the lungs and spleen was always visible after inoculation with any member of Group I. The liver and kidney

lesions were not always to be seen, but they were present in at least one of the animals inoculated with each of these cultures. With respect to their virulence for rabbits and the gross lesions produced, there was no observable difference between the human cultures C No. 4 and E T and the bovine cultures C No. 81 and III.

The cultures of Group II (consisting of cultures F T, F L, S E No. 3, G D, 12124, C No. 1, D T, and 50) showed sharp differences from Group I in the lesions which they produced, although there were considerable variations in the individual rabbits inoculated with the members of Group II. As has been remarked before, the rabbits inoculated with Group II had an average life of 105½ days against an average of less than 20 days for those inoculated with Group I. Certain of the rabbits of Group II, however, survived only 27 days, and, in all, 5 died within 48 days. As the pathologic changes noted in those rabbits of this group which died before the forty-eighth day differed markedly from those seen in the rabbits which had survived a longer time, it will be better to consider the gross changes induced by Group II in two subgroups. Those rabbits of the first subgroup which succumbed within 48 days presented at the autopsy lesions which were very slight when compared with those produced by Group I and which did not seem sufficient to cause death. Indeed, the early death in 2 of the 5 cases might be attributed to a coccidium infection which was present in the livers of both. As to the lesions of tuberculosis seen, all of the 5 rabbits agreed fairly well. The lungs showed slight changes. Sprinkled over their surface were a number of small grayish, almost invisible points usually not more than 0.5 millimeter in diameter. These minute foci showed no coagulation necrosis and were apparently not numerous enough to interfere seriously with the normal functions of the lung, for the tissue outside of the minute tubercles appeared to be perfectly healthy, the lungs collapsing normally when the chest cavity was opened. These areas in the lungs correspond closely with those described by Smith for his sputum rabbits. They become white and plainly visible when immersed in alcohol. In a few of these rabbits some minute grayish points could be seen on the surface of the liver. The spleen and kidneys were normal in size and appearance. Those rabbits inoculated with Group II and which lived a longer time (forming the second subgroup) exhibited lesions which differed markedly from those noted in the rabbits which died at an earlier date, and they were also separated sharply in their macroscopic characters from those produced by Group I. In the rabbits of this latter subgroup, all of which lived more than 79 days, there was extensive involvement of the lungs and kidneys. In the lungs there were large white irregular areas of coagulation necrosis, some having a diameter of 1 cm. The necrotic areas were so extensive as to necessarily interfere seriously

with the function of the lungs. In some of the rabbits which lived the longest a softening had taken place in the necrotic areas and abscesses were produced which contained a rather soft white pus. The liver and spleen in all these animals were apparently normal, while the kidneys were, without exception, extensively diseased, showing on the surface and in the body of the organ white necrotic areas of varying size, some of which had softened.

A careful histologic examination was made of the lungs of all the inoculated rabbits, and, in the case of most of them, the liver, spleen, and kidneys were also studied. The method of embedding and staining was the same as that pursued in the examination of tissues from the guinea pigs. As a result of this microscopic work it is again possible to separate the various cultures into two groups. The lesions caused by Group I are characterized by the distinct necrosis of the central portion of even very young tubercles and by the very great number of tubercle bacilli in them. In the lungs the bacilli were present in enormous numbers. (Pls. IV, V.) This group (I) comprises bovine cultures No. 81 and III and human cultures E T and C No. 4.

The cultures of Group II are the remaining human cultures. In those animals which died within 7 weeks necrotic changes were absent, the tubercles being marked by an accumulation of epithelioid cells; occasionally giant cells could be seen. Tubercle bacilli were usually scarce, only a few being visible in each nodule. The tubercles were fairly numerous in the lungs, but very scarce in the liver, spleen, and kidney. In those rabbits which lived more than 7 weeks the necrotic changes were marked, involving large areas, but the tubercle bacilli were not numerous, except in those areas which had broken down. There they were usually present in considerable numbers.

To recapitulate, the intravenous inoculation of rabbits served to separate the cultures into two groups. Group I (human cultures C No. 4, and E T, and bovine cultures C No. 81 and III) caused the death of the rabbits within 20 days, due to a severe generalized tuberculosis, a necrosis of the central portion of the tubercles being marked, and large numbers of tubercle bacilli being present in the lesions. Group II (human cultures No. 50, F L, F T, S E No. 3, G D, 12124, C No. 1, and D T) caused the death of rabbits after an average of 105 days. Those rabbits which died in less than 48 days did not show sufficient tuberculosis to cause death; necrosis was practically absent and very few tubercle bacilli were found. Those that lived longer than 48 days showed extensive necrotic changes, but in most of the tubercles very few bacilli could be seen.

From the results of the rabbit inoculations which have just been described, the following conclusions may be drawn. It must be remembered, however, that they are based upon results obtained when the rabbits weighed over 1,300 grams, and when the dose was

the same as that already noted. Any considerable variation in either of these two factors might modify the results considerably.

(1) Mammalian tubercle bacilli may be divided into two classes: (a) Those which cause the death of rabbits in 20 days, due to a severe generalized tuberculosis; and (b) those which kill only after several months, or when an earlier death takes place the lesions produced are not severe and necrotic changes are conspicuous by their absence.

(2) The lesions resulting from the inoculation with the virulent cultures are characterized by their wide distribution, rapid necrosis, and by the very great numbers of bacilli in the lesions.

(3) The lesions resulting from the inoculation with the less virulent cultures are characterized by the absence of necrosis in the tubercles in those rabbits which died within 7 weeks, and by the large conglomerate tubercles with extensive necrosis seen in those rabbits which survived for a longer time. Tubercle bacilli were found usually in very small numbers.

(4) Tubercle bacilli of bovine origin, in their action upon rabbits, were indistinguishable from the most virulent human cultures (E. T. and C No. 4).

GENERAL CONCLUSIONS.

The foregoing experiments have been especially striking on account of the widely varying virulence among the human tubercle cultures, and by reason of the fact that those human cultures showing the highest degree of virulence were indistinguishable from the bovine cultures with which they were compared. It is also interesting to note that those human cultures which were identical with the bovine cultures in their virulence for rabbits were also capable of causing a generalized tuberculosis in calves. And in addition only those cultures which caused the death of rabbits within 20 days were capable of bringing about a generalized tuberculosis in calves after subcutaneous inoculation. There seems to be no reason whatever for making a distinction between the two bovine cultures and human cultures C No. 4 and E T, so far as their action upon guinea pigs and rabbits is concerned, and as a result of our experiments the following general conclusions seem unavoidable:

(1) Certain tubercle bacilli of human origin are indistinguishable either culturally, morphologically, or with regard to their virulence for rabbits and guinea pigs from certain tubercle bacilli of bovine origin.

(2) There is considerable variation in the virulence of human tubercle bacilli for rabbits and guinea pigs.

Until we know what influence a residence in the human body exerts upon bovine tubercle bacilli we can not determine accurately the pro-

portion of cases of human tuberculosis which result from infection from cattle.

I am inclined to the belief, from the experiments here presented and from those of Ravenel, Vagedes, Fibiger & Jensen, and others, that in bovine and human tuberculosis we have to do with organisms differing usually in virulence, but between which there is no other essential distinction.

More detailed study of tubercle bacilli derived from accidental inoculation of men with bovine virus is needed, together with a more extended examination of bovine bacilli derived directly from cattle.

TABLE I.—Results of inoculating guinea pigs with cultures of human and bovine origin.

Culture.	Age of culture used.	Total age of culture used.	Number of generations on artificial media.	Culture medium.	Dose of culture.	Mode of inoculation.	No. of animal.	Initial weight of animal.	Date of inoculation, 1902.	Result of inoculation.	Remarks.
	Days.	Days.			c. c.			Gms.			
F T, human.....	30	138	Second	Egg..	0.5	Subcutaneous	G. P. 2072.	472	Aug. 21	Died Aug. 30, 1902, without lesions of tuberculoidea.	^a This animal probably died of pneumonia.
F L, human.....	30	136	Third	do..	.5	do.	G. P. 2073.	527	do.	Died Sept. 23, 1902; generalized tuberculoidea.	Lived 32 days.
Do.....	28	216	Fifth	do..	.5	do.	G. P. 2632.	664	Nov. 11	Died Dec. 4, 1902; tuberculoidea of liver and spleen.	Lived 28 days.
S E No. 3, human..	30	56	Second	do..	.5	do.	G. P. 2075.	527	Aug. 21	Died Sept. 28, 1902; generalized tuberculoidea.	Lived 37 days.
G D, human.....	28	28	First	do..	.5	do.	G. P. 2078.	602	do.	Died Oct. 1, 1902; generalized tuberculoidea.	Lived 40 days.
12124, human.....	58	58	do.	do..	.5	do.	G. P. 2554.	522	Nov. 11	Died Dec. 2, 1902; tuberculoidea of liver and spleen.	Lived 21 days.
C No. 1, human....	22	130	Second	do..	.5	do.	G. P. 2079.	615	Aug. 21	Died Sept. 22, 1902; generalized tuberculoidea.	Lived 31 days.
Do.....	57	57	First	Dog's serum.	.5	do.	G. P. 1329.	424	Mar. 25	Died May 19, 1902; generalized tuberculoidea.	Lived 54 days.
Do.....	57	57	do.	do..	.5	do.	G. P. 1332.	460	do.	Died Apr. 1, 1902; no tuberculoidea of viscera.	^a Lived 6 days.
D T, human.....	30	64	Second	Egg..	.5	do.	G. P. 2074.	477	Aug. 21	Died Sept. 22, 1902; generalized tuberculoidea.	Lived 81 days.
Do.....	28	146	Fifth	do..	.5	do.	G. P. 2633.	500	Nov. 11	Died Dec. 6, 1902; tuberculoidea of liver and spleen.	Lived 25 days.
50, human.....	48	48	First	Dog's serum.	.5	do.	G. P. 1330.	480	Mar. 25	Died Apr. 5, 1902; beginning tuberculoidea of liver and spleen.	^a Lived 11 days.
Do.....	48	48	do.	do..	.5	do.	G. P. 1331.	448	do.	Died May 26, 1902; generalized tuberculoidea.	Lived 61 days.

E T, human	22	83	Second	Egg ..	.5	do	G. P. 2076.	501	Aug. 21	Died Sept. 15, 1902; generalized tuberculosis.	Lived 23 days.
Do.....	50	156	Fourth	do ..	.5	do	G. P. 2591.	621	Nov. 4	Died Nov. 27, 1902; generalized tuberculosis.	Lived 23 days.
C No. 4, human....	18	63	Third	do ..	.5	do	G. P. 2286.	493	Oct. 3	Died Oct. 19, 1902; tuberculosis of liver and spleen.	Lived 16 days.
Do.....	31	96	Fourth	do ..	.5	do	G. P. 2592.	648	Nov. 4	Died Nov. 23, 1902; generalized tuberculosis.	Lived 25 days.
C No. 81, bovine...	30	70	Second	do ..	.5	do	G. P. 2077.	561	Aug. 21	Died Sept. 19, 1902; generalized tuberculosis.	Lived 28 days.
Do.....	70	143	Third	do ..	.5	do	G. P. 2593.	584	Nov. 4	Died Nov. 25, 1902; generalized tuberculosis.	Lived 21 days.
III, bovine	57	57	First	Dog's serum.	.5	do	G. P. 1333.	490	Mar. 25	Died Apr. 16, 1902; tuberculosis of liver and spleen.	Lived 22 days.
Do.....	57	57	do ..	do ..	.5	do	G. P. 1334.	428	do ...	Died Apr. 6, 1902; beginning tuberculosis of liver and spleen.	^a Lived 11 days.

^a Not considered in computing average length of life, not having shown sufficient tuberculosis to account for death.

TABLE II.—Results of inoculating rabbits with cultures of human and bovine origin.

Culture.	Age of culture used.	Total age of culture used.	Number of generation on artificial media.	Culture medium.	Dose of culture.	Mode of inoculation.	No. of animal.	Initial weight of animal.	Date of inoculation, 1902.	Result of inoculation.	Results.
	Days.	Days.			c. c.			Gms.			
F T, human	30	138	Second	Egg	.5	Intravenous	Rab. 462	2,060	Aug. 21	Died Dec. 31, 1902; tuberculous of lungs and kidneys.	Lived 130 days.
F L, human	30	136	Third	do	.5	do	Rab. 465	1,520	do	Died Nov. 9, 1902; generalized tuberculous.	Lived 79 days; weight at death, 1,191 grams.
Do.....	28	216	Fifth	do	.5	do	Rab. 512	1,640	Nov. 11	Died Dec. 13, 1902; tuberculous lesions in lungs.	Lived 32 days; tuberculous very slight.
S E No. 3, human..	30	56	Second	do	.5	do	Rab. 463	1,975	Aug. 21	Died Oct. 9, 1902; generalized tuberculous.	Lived 48 days; very mild type of disease.
G D, human	28	28	First	do	.5	do	Rab. 468	2,300	do	Died Feb. 10, 1903; tuberculous of lungs and kidneys.	Lived 170 days.
12124, human.....	58	58	do	do	.5	do	Rab. 511	1,350	Nov. 11	Died Dec. 27, 1902; tuberculous of lungs.	Lived 46 days; coecidium infection of liver.
C No. 1, human....	22	130	Second	do	.5	do	Rab. 467	2,030	Aug. 21	Chloroformed Mar. 6, 1903; tuberculous of lungs and kidneys.	Lived 193 days; weight at death, 1,676 grams.
Do.....	57	57	First	Dog's serum.	.5	do	Rab. 287	1,925	Mar. 25	Still living Mar. 10, 1903	Apparently in perfect health.
Do.....	57	57	do	do	.5	do	Rab. 289	2,175	do	Died Oct. 1, 1902; tuberculous of lungs and kidneys.	Lived 186 days.
D T, human	30	64	Second	Egg	.5	do	Rab. 464	2,070	Aug. 21	Died Mar. 2, 1903; tuberculous of lungs and kidneys.	Lived 189 days.
Do.....	28	145	Fifth	do	.5	do	Rab. 513	1,350	Nov. 11	Died Dec. 8, 1902; slight tuberculous of lungs.	Lived 27 days.
50, human.....	48	48	First	Dog's serum.	.5	do	Rab. 141	1,627	Mar. 25	Died Apr. 22, 1902; generalized tuberculous.	Lived 27 days; a very mild type of disease.
Do.....	48	48	do	do	.5	do	Rab. 295	2,450	do	Died Aug. 12, 1902; tuberculous of lungs and kidneys.	Lived 142 days.

E T, human	22	Second	Egg...	.5	do	Rab. 466 ..	1,380	Aug. 21	Died Sept. 6, 1902; generalized tuberculosis.	Lived 16 days; severe type of disease.
Do.....	50	Fourth	do ..	.5	do	Rab. 489 ..	1,910	Nov. 4	Died Nov. 19, 1902; generalized tuberculosis.	Lived 15 days; severe type of disease.
C No. 4, human.....	18	Third	do ..	.5	do	Rab. 505 ..	1,594	Oct. 3	Died Oct. 17, 1902; generalized tuberculosis.	Lived 14 days; severe type of disease.
Do.....	31	Fourth	do ..	.5	do	Rab. 488 ..	1,922	Nov. 4	Died Nov. 22, 1902; generalized tuberculosis.	Lived 18 days; severe type of disease.
C No. 81, bovine.....	30	Second	do ..	.5	do	Rab. 460 ..	1,370	Aug. 21	Died Sept. 4, 1902; generalized tuberculosis.	Lived 14 days; severe type of disease.
Do.....	70	Third	do ..	.5	do	Rab. 538 ..	1,612	Nov. 4	Died Nov. 21, 1902; generalized tuberculosis.	Lived 17 days; severe type of disease.
III, bovine	57	First....	Dog's serum.	.5	do	Rab. 139 ..	2,038	Mar. 25	Died Apr. 14, 1902; generalized tuberculosis.	Lived 20 days; severe type of disease.

BIBLIOGRAPHY.

- (1) SMITH, THEOBALD. Trans. Assn. Amer. Phys., 1896—SMITH, THEOBALD. J. Exp. Med., III, Nos. 4-5, 1898.
- (2) RAVENEL. Univ. of Penna. Med. Bull., Sept., 1901.
- (3) RAVENEL. Univ. of Penna. Med. Bull., May, 1902.
- (4) KARLINSKI. Oesterreichische Monatsschr. f. Thierh., 1901, 25, p. 481. (See also Przegląd. Weterynarski, 16, Nos. 11-12, pp. 367 and 401, 1901.)
- (5) VAGEDES. Zeitschr. f. Hyg., Bd. XXVIII, p. 276, 1898.
- (6) LARTIGAU. Journ. of Med. Research, vol. 6 (n. s. vol. I), p. 156. 1901.
- (7) VESZPRÉMI. Cent. f. Bakt., Orig., Abt. I, Bd. 33, No. 3, p. 176. 1903.
- (8) KROMPECHER u. ZIMMERMANN. Centralbl. f. Bakt., etc., I Abt., Orig. Bd. 33, No. 8, p. 580, Apr. 4, 1903.
- (9) STRAUSS. La tuberculose et son Bacille, p. 377.
- (10) PRUDDEN & HODENPYL. N. Y. Med. Journ., vol. 53, p. 697, June 20, 1891.
- (11) STERNBERG, CARL. Cent. f. Allg. Path. u. Path. Anat., XIII, No. 19, 753, Nov. 8, 1902.
- (12) DORSET, M. Amer. Med., III, No. 14, 555, 1902.

(Continued from second page of cover.)

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY—Bulletin No. 52, Part II.

D. E. SALMON, D. V. M., Chief of Bureau.

EXPERIMENTS CONCERNING TUBERCULOSIS,

UNDER THE SUPERVISION OF

THE BIOCHEMIC DIVISION.

PART II.

The Comparative Virulence of Human and Bovine Tubercle Bacilli
for Some Large Animals.

BY

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(Continued on page 3 of cover.)

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY—Bulletin No. 52, Part II.

D. E. SALMON, D. V. M., Chief of Bureau.

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1905.

LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., November 28, 1904.

SIR: I have the honor to transmit herewith a manuscript entitled "The comparative virulence of human and bovine tubercle bacilli for some large animals," by Drs. E. A. de Schweinitz, M. Dorset, and E. C. Schroeder.

When the experimental work described in this manuscript had been practically completed, Doctor de Schweinitz, who was at that time chief of the Biochemic Division of this Bureau, was taken suddenly ill and, to our great sorrow, died. This unfortunate occurrence threw upon the remaining authors of this paper the entire burden of its preparation; together with the formulation of the conclusions expressed therein. In view of this fact Doctor de Schweinitz should be given credit for the active part taken by him in the prosecution of these experiments, but should not be held responsible for the conclusions drawn therefrom.

This manuscript describes the inoculation of cattle, hogs, and monkeys with tuberculous virus of both human and bovine origin and bears directly upon the very important question of the infectiousness of bovine tuberculosis for human beings. I recommend that this manuscript, together with the accompanying illustrations, which are necessary to a thorough understanding of the text, be published as Part II of Bulletin No. 52 of this Bureau.

Respectfully,

D. E. SALMON,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture

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Part II.—THE COMPARATIVE VIRULENCE OF HUMAN AND BOVINE TUBERCLE BACILLI FOR SOME LARGE ANIMALS.

By E. A. DE SCHWEINITZ, PH. D., M. D., MARION DORSET, M. D., AND E. C. SCHROEDER, M. D. V.

The experiments described in this part of Bulletin No. 52 deal almost exclusively with (1) the infectiousness of tubercle bacilli of human origin for hogs and cattle and (2) the comparative virulence of human and bovine tuberculous virus for monkeys. The preliminary notes, indicating the important features of these experiments, have already been published, and it is our desire to present here the details of the experiments, together with a brief review of some of the literature which bears more or less directly upon the work we have done.

PLAN OF THE EXPERIMENTS.

The original plan adopted for these experiments contemplated the following lines of work:

- (1) The isolation of fresh cultures of human tuberculosis from sputum and from cases of generalized tuberculosis in adults and children, obtaining whenever possible material from cases which indicated an involvement of the abdominal viscera.

- (2) The inoculation of cattle and hogs intravenously and subcutaneously with the cultures or material so obtained.

- (3) The feeding of human tuberculous material to calves.

- (4) The isolation of fresh cultures of bovine tubercle bacilli and their use for comparison with the cultures from human beings mentioned above.

- (5) The subcutaneous and intravenous inoculation of cattle and hogs with such bovine cultures or with bovine tuberculous material.

- (6) The inoculation of cattle with bovine and human tubercle bacilli which had been under cultivation in the laboratory for some years and which possessed probably a comparatively low degree of virulence.

It was our plan to trace the histories of the subjects from whom the human tuberculous material was taken and to give complete autopsy records of these persons. The animals which succumbed to inoculation were to be carefully examined after death, and the lesions

found were to be studied microscopically in order to determine if possible whether or not the disease produced was of a progressive character.

Before the experiments progressed very far it became evident that certain of the projected details which seemed quite desirable could not be fully carried out. The subjects from whom the tuberculous material was obtained belonged mostly to the pauper classes, and it was impossible to ascertain with any degree of certainty the sources of their food supply. In addition, the family histories were valueless almost without exception. In other cases from which sputum was obtained no autopsy was made when the subject finally died, owing usually to prejudice on the part of relatives. The records of most of the cases of human tuberculosis are therefore very unsatisfactory in so far as they concern the mode of infection.

But let it be remembered that the primary object of these experiments is to determine whether tuberculosis in cattle may be brought about by tubercle bacilli which have caused serious or fatal disease in man. The source from which the human beings were infected may be of great importance when it can be traced, but it is not necessary to a solution of the problem which we have undertaken.

• METHOD OF OBTAINING THE CULTURES.

Before discussing the general features of the experiments it should be stated that all the cultures used were isolated from guinea pigs which had been inoculated with material from the various cases of human and bovine tuberculosis. As a rule, the cultures were obtained from the spleens of guinea pigs and grown on the egg medium, which is described in detail on page 9 of Part I of this bulletin. In the comparative inoculations the cultures were approximately of the same age and the doses given as nearly uniform as possible.

SOURCES OF HUMAN TUBERCULOUS MATERIAL.

As previously stated, we were unable to secure full data relative to the previous histories and autopsy conditions of many of the cases of human tuberculosis which supplied material for our investigations. In some instances the hospital records, although quite voluminous, were deficient in details of especial interest in experiments of this character; hence only such portions of them as have a direct bearing upon the origin or nature of the tuberculosis with which the several individuals were afflicted will be inserted in this bulletin.

We must express our sincere thanks to the physicians who kindly furnished us with material and records from the several hospitals in this city. The tissue obtained from the Government Hospital for the Insane was sent to us, together with the postmortem records, by

Dr. I. W. Blackburn, the pathologist of that institution. For the material from the Children's Hospital we are indebted to Doctors Grasty and Mason of the house staff, and for the sputum obtained from patients in the Washington Asylum Hospital to Doctor Price, house physician in the asylum.

(1) *Culture F T, human*.—This culture was obtained on egg from the lung of a guinea pig which had been inoculated intraabdominally with sputum from a 45-year-old negro woman whose occupation was that of a domestic. She was admitted to the Washington Asylum Hospital February 16, 1902, after a diagnosis of pulmonary tuberculosis with chronic interstitial nephritis had been made. There was nothing unusual during the course of her illness. She died February 23, 1902. No autopsy could be obtained.

(2) *Culture F L, human*.—This culture was obtained from the spleen of a guinea pig which had been inoculated intraperitoneally with sputum from a painter 40 years old. He was admitted to the Washington Asylum Hospital on June 26, 1902, after a diagnosis of pulmonary tuberculosis had been made. This patient died on November 4, 1902. Consent to a postmortem examination could not be obtained.

(3) *Culture S E No. 3, human*.—This culture was obtained from the spleen of a guinea pig which had been inoculated subcutaneously with a small fragment from the lung of a man 50 years old. This man was admitted to the Government Hospital for the Insane on July 28, 1890, suffering from chronic dementia. Owing to the patient's condition, no evidence could be obtained relative to his previous history. The illness which terminated in his death appeared to begin on September 3, 1901, when he had a chill followed by fever. From that date the temperature varied from 98° to 102° F. On May 15, 1902, the abdomen was distended and the patient vomited copiously. Death took place on May 16.

The autopsy revealed pleuritic adhesions of both lungs. In the left lung old tuberculous deposits were found; in the apex there were some small cavities; secondary tuberculous granulations were scattered throughout the remaining portion of the upper lobe and in patches throughout the lower lobe. In the right lung old tuberculous foci were found in the upper portion and tuberculous nodules throughout the remainder of the organ. The liver had undergone fatty degeneration; the intestines, large and small, were extensively ulcerated; the ulcerations were especially numerous in the small intestine. Many of the mesenteric glands were enormously enlarged, caseous, and some of them softened. A few tubercle bacilli were found in smear preparations from the granulations in the lung, but none could be demonstrated in the caseous material from the mesenteric glands.

(4) *Culture G D, human*.—This culture was obtained from the spleen of a guinea pig which had been inoculated with a small fragment of a peritoneal tubercle from a man 19 years old. The man was admitted to the Government Hospital for the Insane on February 11, 1902, suffering with acute mania associated with generalized tuberculosis. The tuberculosis apparently began about three months before admission to the hospital. The temperature ranged from 99° to 101.8° F. The sputum contained a very small number of tubercle bacilli. The patient gradually lost strength after admission, and died on May 7, 1902.

The autopsy revealed the following lesions: The lungs were adherent to the thoracic wall, except at the lower part of the left pleural cavity, where there was evidence of an old tuberculous empyema. Many miliary tubercles were scattered throughout both lungs but very few cavities were found. The bronchial glands were enlarged and caseous. The omentum, intestine, and all abdominal viscera were so bound together by inflammatory adhesions that it was impossible to remove any of the organs. The surface of the peritoneum was covered with yellowish white tuberculous masses ranging in size from a pin's head to one-fourth of an inch in diameter. The liver contained numerous tuberculous areas, some of which had broken down and produced cavities. The spleen was full of large tubercles; the kidneys showed numerous medium-sized tubercles. The intestines were matted together by adhesions and their mucous surface presented numerous small ulcers. There was also a tuberculous inflammation of the meninges of the brain. From the character of the disease it was impossible to determine accurately the mode of infection; it appeared probable, however, that the bronchial glands were the first of the internal organs to be involved, and it is not unlikely that the infection entered through the mouth or throat.

(5) *Culture No. 12,124, human*.—This culture was obtained from the spleen of a guinea pig which had been inoculated with a small fragment of the lung of a woman about 27 years of age. The woman was admitted to the Government Hospital for the Insane in November, 1900. She was an Indian, and was suffering from a form of congenital imbecility. She had lived the greater portion of her life in the woods, subsisting upon berries, game, and food which was voluntarily given to her. No detailed family history was obtainable. At the time of admission there was no suspicion of tuberculosis, but she began to fail shortly afterwards. She died on June 26, 1902.

The following synopsis of the postmortem lesions was kindly furnished us by Doctor Blackburn:

1. Tuberculous pleuritis, nodular, left side only.
2. Pulmonary tuberculosis with perforation.
3. Pneumothorax and pulmonary collapse.
4. Tuberculous ulceration of the intes-

tines. 5. Tuberculous lymphadenitis; mesenteric glands. 6. Tuberculous salpingitis with adhesions. 7. Perforation and localized peritonitis due to ulceration and adhesions of bowel in pelvic cavity. 8. Fatty infiltration of liver. 9. Moderate degree of interstitial nephritis. 10. Slight chronic lepto-meningitis and atrophy of brain. 11. Dilatation of left side of heart and cardiac thrombosis.

Remarks: The brief synopsis given shows the extent of distribution of the tuberculous lesions. The pulmonary disease seems to be ordinary acute phthisis. The pleural disease was unusual in that it was nodular and accompanied by active inflammation and was limited to one pleural cavity, the left. The nodules bore a considerable degree of resemblance to the pearl disease of cattle, a condition I do not often find. The intestinal ulcers were large and completely encircled the bowel. The primary seat of infection was probably the lungs.

(6) *Culture C No. 1, human.*—This culture was obtained from the spleen of a guinea pig which had been inoculated with a small fragment of a mesenteric gland from a child 19 months old. This child was admitted to the Children's Hospital on November 20, 1901. No family history could be obtained. The general history of the patient is as follows: A male child, fed partly at the breast and partly on cow's milk; had never enjoyed good health. On examination after admission to the hospital he was found to be markedly rachitic, and had a dull, apathetic expression. He was affected with a loose cough and his respiration was rapid and shallow. Mucous râles could be heard throughout the chest and some consolidation at the apex of the left lung was detected. The gastric and intestinal digestion was poor, but a physical examination of the abdomen failed to reveal anything abnormal. The patient gradually lost in condition from the time of his admission; appetite was and remained very poor, the pulse was rapid and weak, and he gradually passed into a moribund condition and died on December 22, 1901.

The autopsy record, which was kindly furnished us by Doctor Grasty, is as follows, the portions which have no direct bearing on tuberculosis being omitted:

Thorax: The diaphragm was adherent to the base of the right lung. There was a general adhesive pleurisy on this side with imperfect crepitation of the lung, which was mottled and grayish and studded with miliary tubercles which were especially numerous over the superior lobe and in the region of the apex. A cavity in the apex was about the size of a hazelnut. The left lung was consolidated at the apex. There was imperfect crepitation throughout the organ, and miliary tubercles from 1 to 5 mm. in size could be seen throughout the lung tissue. The lower lobe contained two large cavities filled with purulent material and threads of necrotic tissue. A microscopic examination of the contents of these cavities revealed the presence of many tubercle bacilli. The tracheobronchial glands were enlarged and caseous. Both pleuræ were studded with tubercles. The brain was congested and at its base some tubercles and a serous exudate were found. There were also tubercles in the cerebellum and fourth ventricle. In the abdominal cavity the liver was enlarged and mottled but showed no signs of tuberculosis. The spleen was enlarged and infiltrated with tubercles. The intestine was generally hyperemic. In the duodenum, the jejunum, and the ileum, at intervals of from 3 to 6 inches, were a number of ulcerations, some flat and broad, others deep, punched out, and undermined, all ulcers running transverse to the axis of the intestine. Scrapings from the ulcers revealed tubercle bacilli. In the caput coli there were two

large ulcerated areas, one just above the ileocecal valve, $1\frac{1}{2}$ inches in length and one-half inch wide and the other just at the ileocecal valve, 1 inch long and very irregular in outline. A number of tuberculous ulcers were found in the colon also. Many of the mesenteric glands were enlarged and caseous.

Guinea pigs were inoculated from the spleen and from the mesenteric glands, and all died of tuberculosis.

(7) *Culture D T, human.*—This culture was obtained from the spleen of a guinea pig which had been inoculated with a small fragment of the lung of a girl 5 years old. The girl was admitted to the Children's Hospital February 28, 1902. The family history was negative. The child was reported to have been ill for approximately three months. On admission to the hospital her temperature ranged from 101° to 107° F. The clinical symptoms warranted a diagnosis of tubercular meningitis associated with pulmonary tuberculosis. The child died on March 10, 1902.

The autopsy was briefly as follows:

Some exudate at the base of the brain; the heart was normal; in the right lung there were a few tubercles. Hemorrhagic areas and tubercles were also found in the upper and lower lobes of the left lung. The liver was softened in places and old adhesions were found on its superior surface. The spleen was soft and exhibited old adhesions. The mesenteric glands were normal, as were the intestines and kidneys. There is nothing in the autopsy record to indicate infection by way of the digestive tract. Smear preparations from one of the lung tubercles showed a few tubercle bacilli.

(8) *Culture E T, human.*—This culture was obtained from the spleen of a guinea pig which was inoculated with a small fragment of a mesenteric gland from a girl 12 years old. The girl had been treated twice in the Children's Hospital for tubercular peritonitis and apparently cured. The first attack occurred during the winter of 1900 and the second in March, 1901. On July 6, 1901, she returned to the hospital suffering from a tuberculous arthritis of the elbow joint. In December, 1901, a complete excision of the joint was made and the child progressed well after the operation. On February 22, 1902, a cold abscess on the back of the neck was opened. On March 8, she began to complain of slight abdominal pain; the temperature rose gradually and the vomiting which occurred was followed rapidly by stupor which deepened into coma and the child died on the morning of March 9. The temperature shortly before death was 108.8° F. There was nothing in the history of this child to indicate the mode of infection.

The autopsy report, which was furnished us by Doctor Mason, is as follows:

Pleuritic adhesions on both sides. The lungs were free from tuberculosis; the heart was small and flabby. The abdominal cavity contained considerable fluid mixed with blood, pus, and intestinal contents. The omentum was much thickened and contained

a large number of small tubercles. The omentum and intestines were adherent to the parietal peritoneum. The spleen was large and filled with tubercles; the kidneys were large and soft, but not tuberculous. The liver was very friable and filled with tubercles. The intestines were bound to the peritoneum and the neighboring coils were firmly adherent to each other. There were numerous caseous mesenteric glands; numerous ulcers distributed throughout the ileum. The lower portion of this section of the small intestine was constricted by bands of adhesive tissue and an area of about 7 inches was greatly congested and almost gangrenous. Just above this congested area were two perforations through small ulcers.

Smear preparations made from the mesenteric glands did not show any tubercle bacilli, but the guinea pigs which were inoculated with the same material developed the disease.

(9) *Culture C No. 4, human.*—This culture was obtained from the spleen of a guinea pig which had been inoculated with a small fragment of a peritoneal tubercle from a boy 5 years old. This child was admitted to the Children's Hospital on April 4, 1902. The family history and previous history of the patient as determined at the hospital were as follows: The parents were both alive and healthy, and had lost no children. The only other child was in good health. There was a history of some tuberculosis in the mother's family. The boy when an infant had been reared on condensed milk and until the time of his present illness was said to have been a healthy child. During the summer and fall of 1901 ascites developed and the child was confined to bed for two weeks, the effusion disappearing, but a hard mass remained in the region of the umbilicus. During October, 1901, the patient developed pertussis, and the cough persisted until the time of admission to the hospital. About two weeks before entering the hospital, during coughing, a rupture of the abdominal wall occurred and an intestinal fistula resulted. When admitted to the hospital the child was extremely emaciated, had a severe cough, fever at night, seemed constantly disposed to sleep, and had no appetite. The patient did not improve in the hospital, and died six days after admission.

The autopsy was briefly as follows:

There was a generalized tuberculosis of the thoracic and abdominal viscera involving the lungs, spleen, liver, intestines, and lymph glands. The peritoneum and mesentery contained many tubercles. The mesenteric glands were generally caseous and enlarged. In the lower portion of the ileum was a perforation which connected with a cavity (completely walled off from the peritoneal cavity) which communicated with an opening at the site of the umbilicus. The intestines were so firmly bound down by adhesive tissue that it was exceedingly difficult to trace their course. No ulcers were found. The peritoneal tubercles were examined microscopically but no bacilli found. The guinea pigs which were inoculated developed tuberculosis. It seems probable that the infection in this case as well as in the preceding one, had its origin in the abdominal cavity, but from the rather meager details of the autopsy which are obtainable

it is impossible to speak definitely in regard to this matter. On account of the age of the child and its previous good health, the infection most probably took place at some time subsequent to the date when it was weaned from its bottle.

(10) *Cultures Nos. 49 to 60.*—These cultures were of human origin. They had been grown in the laboratory for a number of years on liquid media and still retained the characteristic virulence for guinea pigs.

(11) *Cultures A 101 to A 125.*—These cultures represent different generations of the attenuated culture which has been under cultivation in the Biochemic Division for about ten years. Culture A 125 is the one hundred and fiftieth generation on glycerinized bouillon. This culture was originally received from Doctor Trudeau, who states that it was obtained by himself in 1891 directly from a case of miliary tuberculosis in man. It was afterwards passed through a rabbit and then cultivated on various artificial media. While entirely avirulent for guinea pigs, it has the property of producing in cultures the substance which causes the fever reaction in tuberculous animals, and has for a long time proved very satisfactory for the preparation of tuberculin.

(12) *New York culture, human.*—This culture was obtained December 21, 1901, from a tuberculous lung which was sent to us by Doctor Lartigau, of the College of Physicians and Surgeons in New York. Similar material was also secured from New York on January 6, February 10, and March 3, 1902.

(13) *Sputum, human.*—This material was used for the inoculation and drenching of cattle.

SOURCES OF BOVINE TUBERCULOUS MATERIAL.

(14) *Culture bovine III (Smith).*—This was given us several years ago by Dr. Theobald Smith and since then has been cultivated continuously on glycerinized bouillon.

(15) *Culture C No. 81, bovine.*—This culture was obtained from the spleen of a guinea pig which had been previously inoculated with a fragment of a mediastinal gland from cow No. 81. This animal—cow No. 81—was affected with tuberculosis of spontaneous origin.

Record of cow No. 81: About 5 years old; June 25, 1901, tested with tuberculin; reacted; was removed from the healthy animals and placed in a stable with a number of other cattle which had also reacted to tuberculin; August 26, 1901, had a moist, dry cough, respiration regular and not labored; January 2, 1902, was removed to another stable and confined continuously in a box stall adjoining stalls in which other tuberculous animals were kept. Killed March 13, 1902, and examined postmortem.

Autopsy: Right lung is a solid mass of tubercles excepting a small area at the superior posterior portion of principal lobe. Left lung contains many tuberculous areas, but is not affected to so great an extent as the right one. The tuberculous masses, on section, are found to contain lime salts, and many are broken down. There are also a number of distinct cavities which are partially filled with a gelatinous material. These cavities communicate with the bronchi, which, as well as the trachea, contain a large amount of the above material. The mediastinal glands are enlarged and are converted into masses of tubercles separated from each other by thickened connective tissue. These tubercles, on section, are found to consist of a firm, cheesy material, which contains lime salts. Liver contains several characteristic tuberculous nodules. Spleen apparently normal. Nearly all of the mesenteric glands contain one or more tuberculous foci.

(16) *Bovine tuberculous tissue*.—Material obtained from various cases of spontaneous tuberculosis in cattle.

EXPERIMENTS UPON HOGS.

It will be remembered that Professor Koch^{1a} announced that he had been unable to produce generalized tuberculosis in hogs by subcutaneous inoculations with pure cultures of human origin. In order to determine the correctness of his views we inoculated ten hogs—some with human tuberculous material and some with pure cultures of the human tubercle bacillus—and also one pig with a bovine culture, the latter animal serving as a comparison with those inoculated with human virus. As will be seen from the gross appearance of the various organs obtained from some of these animals, there is little or no difference between the animals inoculated with bovine and human tuberculous material (Pls. VI, VII, VIII, human, and X, XI, XII, bovine). In the case of one pig no disease was produced by inoculation with a human culture. This culture proved to be quite low in virulence for all of the domesticated animals which were exposed to it. The detailed records of the hogs follow:

Record of hog No. 230.—January 29, 1902, tested with tuberculin, without reaction. April 19, 1902, weight 57½ pounds. Injected subcutaneously inside of right thigh with 1½ c. c. of a suspension of human culture C No. 1 prepared in the following manner: The colonies of tubercle bacilli were scraped from the surface of four dog-serum culture tubes and a watery suspension of them made by adding 18 c. c. of sterile water. A portion of this suspension, which was moderately turbid, was used to inject the animal. September 9, 1902, killed and examined postmortem.

Autopsy: In good condition; no lesions of tuberculosis.

^aThese figures refer to bibliography on page 98.

Record of hog No. 226.—April 12, 1902, weight before injection, 51 pounds; tested with tuberculin before inoculation without reaction; a piece of thickened tuberculous human intestine, same source as human culture C No. 4, introduced beneath the skin inside of the left thigh; the usual technique employed. September 9, 1902, the animal killed and examined postmortem.

Autopsy: The entire lung was sprinkled with areas of tuberculosis; the left median lobe completely solidified; the bronchial and mediastinal glands greatly enlarged and entirely tuberculous; portal glands similarly affected; a number of necrotic foci in the liver.

Guinea pigs Nos. 2300 and 2301 were each inoculated subcutaneously with a small fragment of a mediastinal gland from this hog and as a result died of a generalized tuberculosis.

Record of hog No. 229.—April 12, 1902, weight 58 pounds; tested with tuberculin before inoculation without reaction; a piece of thickened tuberculous intestine introduced beneath the skin on the inside of the left thigh; the usual technique employed; same material as that used for hog No. 226. September 9, 1902, killed; in good condition.

Autopsy: Sprinkled throughout the lung are numerous minute white points surrounded by a zone of semitransparent material. The mediastinal glands show a number of minute necrotic areas and are slightly enlarged; liver sprinkled with small areas of necrosis, and the portal glands are enlarged and filled with necrotic material; more or less disease of the omentum and serous surface of the intestines, resembling pearl disease; several necrotic areas in the spleen.

The tissue used to inoculate hogs Nos. 226 and 229 was from the same source as that used for obtaining the culture with which hog No. 460 was inoculated.

Record of hog No. 460.—This animal was not tested with tuberculin before inoculation, but was in a perfectly healthy condition at that time. October 13, 1902, injected subcutaneously inside of left thigh with 2 c. c. of human culture C No. 4. This animal showed signs of illness on October 30. The disease advanced quite rapidly, the animal exhibiting a cough, labored respiration, and a poor appetite until November 11, when it was in a dying condition and was killed.

DESCRIPTION OF PLATE IX.

Sections of organs of hogs inoculated subcutaneously with cultures C No. 4 and E T, human, tuberculosis. Stained with hematoxylin and carbol-fuchsin. Magnified 1,450 diameters.

Fig. 1.—Section of lung of hog No. 457, inoculated with culture E T.

Fig. 2.—Section of spleen of hog No. 457, inoculated with culture E T.

Fig. 3.—Section of liver of hog No. 457, inoculated with culture E T.

Fig. 4.—Section of lung of hog No. 460, inoculated with culture C No. 4.

Drawing by W. S. D. Haines.



Lung hog 460. Subcutaneous inoculation with pure culture human tuberculosis No. C 4.

Liver hog 400. Subcutaneous inoculation with pure culture human tuberculosis No. C 4.



Spleen hog 457.

Subcutaneous inoculation with pure culture human tuberculosis No. E. T.



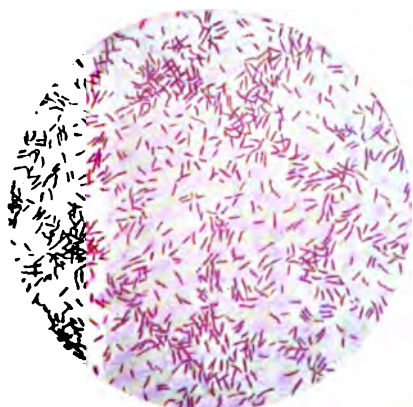


Fig. 1.



Fig. 2.

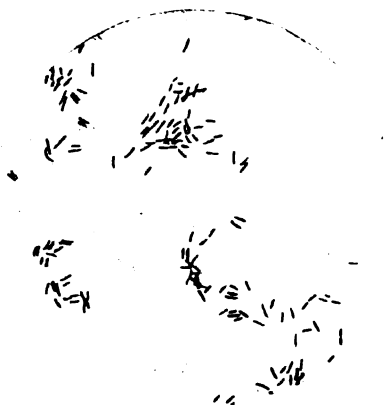


Fig. 3.



Fig. 4.

Autopsy: Some swelling and slight necrosis of tissue on the inner side of the left thigh was noted. Lymphatic system: (1) Left inguinal glands much enlarged, containing many small yellowish nodules visible on surface of the glands; (2) right inguinal gland and (3) right lumbar gland apparently normal; (4) retroperitoneal glands enlarged; (5) posterior mediastinal glands enlarged, size of pigeon's egg. Spleen very dark red in color; the surface is quite rough and nodular; there is, however, no sign of caseation in the nodules. Liver is paler than normal, and scattered thickly over its surface are grayish white areas, fairly well defined and about the size of a pinhead. Kidneys rather dark, but otherwise normal. Intestines not inflamed, but mucous surface of cecum is covered with a thick white exudate, which is easily peeled off, leaving the intestine beneath in a fairly healthy condition. Lungs have a general pearl-gray color and scattered over their entire surface numerous very minute whitish areas can be distinguished. (See Pls. VI and VII.)

Microscopical examination: Lung—A number of well-defined tubercles with necrotic centers; the tubercles contain a fair number of tubercle bacilli. Liver—A large number of miliary tubercles with necrotic center; occasionally a giant cell can be seen; a few tubercle bacilli are present in some of the tubercles. Spleen—A number of more or less circumscribed areas of necrosis are visible; these areas contain a very few tubercle bacilli. Mediastinal glands—There is considerable necrosis of the cellular tissue and a very few tubercle bacilli are present. Mesenteric gland—A few necrotic areas and a few tubercle bacilli were noted. Left inguinal gland—Large areas of necrosis which contain a few tubercle bacilli. Left lumbar gland—Large areas of necrosis containing very numerous tubercle bacilli. Intestinal exudate—No tubercle bacilli were found.

Record of hog No. 459.—Tested with tuberculin before inoculation without reaction. January 24, 1903, weight 40 pounds; injected subcutaneously inside of left thigh with 2 c. c. of a thin suspension of human culture C No. 4. This animal appeared to be in good condition until June 2, 1903, when it was killed and examined post-mortem, lesions of generalized tuberculosis being found.

Record of hog No. 457.—This animal was not tested with tuberculin prior to inoculation, but was in a perfectly healthy condition on October 13, 1902, when it was injected subcutaneously inside of left thigh with 2 c. c. of a thin suspension of human culture E T. This animal gradually lost in condition and died on December 13, 1902.

Autopsy: There was some swelling at seat of inoculation. Lymphatic system—(1) Left inguinal glands very much enlarged and firm; (2) right inguinal glands normal in size and appearance upon section; (3) right lumbar glands apparently normal; (4) retroperi-

toneal glands enlarged and tuberculous; (5) posterior mediastinal glands very slightly enlarged. Abdominal viscera—(1) Liver about normal size, mottled, and rather light in color; (2) spleen about normal in size, covered with light-red nodules about size of a half pea, some smaller, which are raised above the surface of the organ—a typical tuberculous hog spleen (see Pl. VIII); (3) kidneys congested. Thoracic viscera—(1) Heart, slight pericardial effusion; (2) lungs both gray and almost completely solidified, a number of small grayish points over the surface.

Microscopic examination: The several organs showed as follows: Lung—Large areas are solidified and necrotic; many of the alveoli are filled with cellular débris in which are enormous numbers of tubercle bacilli. Liver—There are large numbers of minute tubercles in the section; these tubercles contain numerous tubercle bacilli. Spleen—A number of large, fairly-well defined tubercles with necrotic centers are to be noted; these tubercles contain great numbers of tubercle bacilli. Mediastinal gland—Contains a moderate number of tubercle bacilli. Left inguinal gland—Tubercle bacilli are present in enormous numbers. Left lumbar gland—Tubercle bacilli are found in enormous numbers.

Record of hog No. 455.—Tested with tuberculin before inoculation, without reaction. January 24, 1903, weight 44 pounds; injected subcutaneously inside of left thigh with 2½ c. c. of a thin suspension of human culture E T. This animal showed no especial signs of illness as a result of the inoculation, but when killed on June 2, 1903, exhibited the lesions of generalized tuberculosis.

Record of hog No. 483.—Tested with tuberculin before inoculation but did not react. January 24, 1903, weight 35½ pounds; injected subcutaneously inside of left thigh with 2 c. c. of a thin suspension of bovine culture C No. 81. March 3, 1903, losing in condition; respiration labored and accelerated; has a tumor at seat of injection about 2 by 2½ inches in size. This hog failed rapidly and died March 9, 1903.

Autopsy: Slight inflammation was found on inside of left thigh; left inguinal gland enlarged and caseous; right inguinal glands normal; left lumbar gland considerably enlarged; mediastinal glands somewhat enlarged. Spleen slightly enlarged and dotted with small round pale areas, some of which are slightly raised above the surface of the organ. Liver has scattered over its surface a fair number of small grayish areas the size of a pinhead or smaller. Lungs were both distended and did not collapse when the thoracic cavity was opened; there was a red hepatization of the cephalic lobes of both lungs; the principal lobes were generally grayish in color and were sprinkled with minute translucent gray areas. (See Pls. X, XI, and XII.)

TABLE III.—*Inoculation of hogs subcutaneously with human and bovine tuberculosis.*

Material used.	Dose.	Number of animal.	Date of inoculation.	Result of inoculation.
Human culture E T	c. c. 2	Hog No. 457 ^a	Oct. 13, 1902	Died Dec. 13, 1902.
Do.....	2.5	Hog No. 455 ^b	Jan. 24, 1903	Remained in fair condition.
Human culture C No. 4	2	Hog No. 400 ^c	Oct. 13, 1902	In dying condition when killed.
Do.....	2	Hog No. 459 ^b	Jan. 24, 1903	Remained in fair condition.
Bovine culture C No. 81	2	Hog No. 483 ^a	do.....	Died March 9, 1903.
Human culture C No. 1	1.5	Hog No. 230 ^d	Apr. 19, 1902	Remained well.
Human intestine (tuberculous).	Small piece.	Hog No. 226 ^c	Apr. 12, 1902	Remained in fair condition.
Do.....	do	Hog No. 229 ^c	do.....	Remained fairly well.

The following footnotes show the condition of the hogs after death:

^a Generalized tuberculosis.

^d Killed Sept. 9, 1902. No tuberculosis.

^b Killed June 2, 1903. Generalized tuberculosis.

^c Killed Sept. 9, 1902. Generalized tuberculosis.

^c Killed Nov. 11, 1902. Generalized tuberculosis.

DISCUSSION OF HOG EXPERIMENTS.

From the experiments which have just been described it will be seen that of three cultures of tuberculosis from children, one proved to be practically without virulence for hogs, while the other two induced a generalized tuberculosis which was quite as severe as the disease caused by the bovine bacillus in hog No. 483. The gross lesions brought about in the hogs by the more virulent human cultures and the bovine culture are very well depicted in the accompanying plates (VI to XII).

All the hogs used for these inoculations were in a perfect state of health at the beginning of the experiments.

As a result of these experiments upon hogs, the conclusion is justified that—

1. Certain tubercle bacilli of human origin possess quite as great pathogenic power for hogs as tubercle bacilli of bovine origin.

2. The disease induced in hogs by human cultures, C No. 4 and E T, was distinctly progressive in character, death taking place in two of the animals in twenty-eight and sixty days, respectively:

EXPERIMENTS UPON CATTLE.

Every precaution was taken to avoid the possibility of error in these experiments. In all cases perfectly healthy animals were selected, and no cattle were included in the experiments that had not failed to respond to the tuberculin test. Each animal was kept, after inoculation, in a clean, separate stall, where there was no opportunity for the contraction of disease from other animals. The cattle were inoculated subcutaneously, intraabdominally or intravenously, and some were fed or drenched with tuberculous material. In some instances it was possible to inoculate or drench

cattle with human tuberculous tissue and later to inoculate others with pure cultures derived from the same human tissue. By this method we hoped to determine whether the virulence of the organism in question was heightened or lowered during the process of its isolation in pure culture. The dose given the cattle varied somewhat, but was in the main fairly uniform and not excessive, as will be seen by the examination of the records which follow.

INTRAVENOUS INOCULATIONS

Record of heifer calf No. 270.—About one year old; tested with tuberculin without reaction. September 16, 1902, injected with 5 c. c. of a suspension of human tubercle culture F T in right jugular vein. The first symptom of illness was noted on September 25, when the respiration was accelerated. The respiratory disturbance became gradually more marked and the general condition of the animal became worse until about the 17th of October, 1902, at which time signs of improvement were noted. The animal continued to gain rapidly in condition and appetite, and the respiration became normal.

On January 24, 1903, the animal, apparently in perfect health, was inoculated subcutaneously in front of the right shoulder with 5 c. c. of bovine III tubercle culture. As a result of the inoculation with the bovine virus a tumor, 2 by 3 inches in size, developed at the point of inoculation, and the neighboring prescapular gland became considerably enlarged. On May 19, 1903, a soft tumor of considerable size was visible at the point of inoculation; the prescapular gland had returned to its normal size. The enlargement on the side of the neck began to discharge a thick creamy pus on July 27, 1903. On October 24, 1903, a tuberculin test of this animal gave no reaction. The heifer was killed on November 2, 1903, and examined postmortem.

Autopsy: The autopsy showed no lesions of disease. The human culture had evidently not only failed to infect this animal but, on the contrary, apparently had produced an immunity, although such a supposition is open to the rather serious objection that there was no control to prove the pathogenic power of this particular bovine culture for normal cattle.

Record of calf No. 275.—Age, about 9 months; tested with tuberculin previous to inoculation, but did not react. September 16, 1902, injected with 5 c. c. of a suspension of human culture F L into right jugular vein; weight at time of inoculation, 186 pounds. On September 27 the animal was losing in condition and its respiration was accelerated. This calf became gradually weaker until November 3, 1902, when it was killed and examined postmortem.

Autopsy: The pleuræ were considerably thickened and opaque; the lungs showed numerous very minute foci of disease, and the same was true of the liver and kidneys. The mediastinal glands were enlarged, congested, and had the appearance of beginning tuberculosis.

Microscopic examination: Lung—Most of the air spaces in the section are filled with desquamated epithelial cells and leucocytes; there is a slight general increase in connective tissue throughout section; no areas of necrosis were found, but numerous long, well-stained, beaded tubercle bacilli were visible. Kidney—Rather severe cloudy swelling; no distinct tubercles found, but a few long faintly stained tubercle bacilli could be seen. Mediastinal gland—A number of ill-defined areas of coagulation necrosis and a very few long, slender, faintly stained tubercle bacilli.

Although this animal was made quite sick by the intravenous injection of culture F L, the tuberculous lesions found at the autopsy were not progressive in character, and seemed to be hardly greater than might have been expected from the mechanical irritation and the toxic action of the bodies of the injected bacilli. We must consider this case, therefore, as one in which human bacilli failed to produce a true tuberculosis in cattle after intravenous inoculation.

Record of calf No. 272.—About 8 months old; weight, 244 pounds. September 10, 1902, tested with tuberculin, without reaction. September 15, 1902, injected 5 c. c. of human tubercle culture S E No. 3 into right jugular vein. As a result of this inoculation the animal exhibited considerable disturbance of respiration, but did not lose very much in condition.

On December 8, 1902, the calf appeared to be again in a perfect state of health, and having remained well, it was inoculated subcutaneously in front of right shoulder with 5 c. c. of a suspension of bovine tubercle culture III on January 24, 1903. This inoculation of bovine culture produced an extensive local swelling which, in course of time, softened and discharged a thick, creamy pus; the general condition of the animal, however, remained good. On November 6, 1903, this calf was killed and examined postmortem.

Autopsy: The lungs contained a number (50 to 75) of small nodules, which varied in size from 1 to 5 mm. These nodules had a pearl-gray glistening appearance, and in a few instances were surrounded by a zone of congestion. The epicardium showed a little roughening along the groove between the two ventricles. At the seat of the inoculation with the bovine culture the subcutaneous tissues were greatly indurated and sprinkled with several tubercular nodules, which contained a soft, creamy pus. The lymph gland near this point was greatly enlarged, but showed only one nodule of tuberculosis, about $1\frac{1}{2}$ cm. in diameter, which contained thick,

creamy pus. Guinea pigs inoculated with fragments of a minute nodule in the lung did not contract tuberculosis.

It is difficult to say positively whether the pulmonary nodules were referable to the intravenous inoculation with human culture S E No. 3 or whether they were caused by the later subcutaneous inoculation with bovine culture III. It seems probable, however, in view of the fact that the bovine virus did not affect the deeper lymph glands, that the nodules in the lungs were caused by the injection of the human tubercle culture. This pulmonary disease was, however, not progressive; the pathological changes were very slight, and apparently did not interfere with the health of the animal, notwithstanding the fact that fourteen months had elapsed between the date of inoculation and the autopsy. On this account we are inclined to consider this inoculation negative in so far as the production of tuberculosis by culture S E No. 3 is concerned.

Record of calf No. 271.—Age, about 8 months; weight, 226½ pounds. September 10, 1902, tested with tuberculin without reaction. September 16, 1902, injected 5 c. c. of human tubercle culture G D into right jugular vein. This animal began to show symptoms of a respiratory disturbance on September 27. This continued for some time without very great effect upon the general health of the calf. On November 4 a rather severe conjunctivitis was noted. This was accompanied by a profuse serous discharge from the eyes. This inflammation did not improve, but, on the contrary, became continually worse. In addition, the animal suffered from a severe diarrhea, which began on November 6 and continued until its death. On November 26 the calf, being in a helpless condition, was killed.

Autopsy: No gross lesions were found, with the exception that the mediastinal glands contained several necrotic foci, the eyeballs were coated with a semiopaque membrane, and the mucosa of the fourth stomach was sprinkled with many elevations. These elevations were from one-eighth to three-sixteenths inch in diameter, and had depressed centers. Liver, spleen, and kidney normal. Lung mottled; some areas of consolidation. Mediastinal glands, rough and nodular. Fourth stomach—The mucous surfaces show some very small white ulcers, and attached to the peritoneal surface are a few nodules the size of a pea.

Microscopic examination: Lung—Numerous slender, beaded tubercle bacilli were found in smear preparations from this organ. In the nodules on peritoneal surface of fourth stomach a moderate number of long, slender, beaded tubercle bacilli were found. In smear preparations from a small ulcer on mucous surface of fourth stomach a few slender, beaded bacilli were found.

In the absence of intestinal lesions of tuberculosis, the severe diarrhea from which this animal suffered can hardly be ascribed to

that cause, and as the poor condition of the animal was evidently due directly to the diarrhea, it must be granted that death was not due to the inoculation with the human tubercle bacillus. It is of interest to note, however, that two months after the inoculation macroscopic lesions of tuberculosis, together with tubercle bacilli, were present in the lung and on both the serous and mucous surfaces of the fourth stomach. On the mucous surface of the fourth stomach there was some destruction of tissue..

Record of calf No. 289.—About six months old. October 11, 1902, tested with tuberculin without reaction. October 14, 1902, inoculated intravenously with 5 c. c. of human tubercle culture 12124.

The history of this calf is quite similar to that of calf No. 271. The inoculation with tubercle bacilli produced an accelerated respiration after a time, but the health of the animal did not seem to be seriously impaired until December 20, when an inflammation of the eyes was noted. This affection of the eyes became gradually worse, and was accompanied by a severe diarrhea, the animal losing continually in condition. On February 12, 1903, it was killed. At the autopsy the lungs were found to be sprinkled with a considerable number of small tumors, probably due to the action of tubercle bacilli. This case must be viewed as another failure to produce a progressive tuberculosis in calves by the intravenous injection of human tubercle bacilli, although localized changes were produced in the lungs.

Record of calf No. 273.—About 8 months old; weight 240 pounds. September 10, 1902, tested with tuberculin without reaction. September 15, 1902, injected 5 c. c. of a suspension of human tubercle culture C No. 1 into right jugular vein. The animal exhibited no ill effects as a result of the injection.

On January 24, 1903, it was injected subcutaneously in front of right shoulder with 5 c. c. of a suspension of bovine tubercle culture III. This injection produced quite a large local swelling after a time, and the adjacent prescapular gland became considerably enlarged; the general condition of the animal remained good. On May 18 the local swelling had diminished and the prescapular gland had returned to its normal size. The general condition of the animal remained good, although the tumor at the seat of injection persisted until October 24, 1903, when the calf was tested with tuberculin and a reaction obtained. The animal was killed on November 13, 1903, and examined post-mortem.

Autopsy: General condition good. A tumor about 2 inches long and 1 inch thick, consisting of a thin wall inclosing a mass of thick, soft pus was found at the seat of injection on the right side. The gland adjacent to the injection tumor is greatly enlarged and contains several tubercles 5 mm. in diameter. Other superficial glands are normal. Lung—Mediastinal glands are considerably enlarged, but

free from disease; sprinkled over the pleura of the lung are numerous tubercles from 1 mm. to 5 cm. in diameter; a few small tubercles in the lung tissue proper; the number of tubercles on the costal pleura and on both sides of the diaphragm. Liver—Several tubercular masses on the surface of the liver from 1 to 3 cm. in diameter. Other organs normal.

Owing to the absence of any symptoms of illness following the inoculation with the human culture, the lesions found at the autopsy must be attributed, at least in great part, to the action of the bovine bacilli. This calf did not, therefore, acquire immunity from the bovine bacillus as a result of the previous intravenous injection with the human culture.

Record of calf No. 264.—Age about 5 months. Tested with tuberculin, but did not react. August 9, 1902, injected $5\frac{1}{2}$ c. c. of a suspension of human tubercle culture E T into jugular vein. No symptoms of illness were noted until August 19, when the respiration was accelerated and the temperature high. From this date until the day of its death the animal became rapidly worse. There was loss of appetite, listlessness, emaciation, and an uncertain gait. The respiration was short and jerky, with an occasional cough. On August 29, 1902, twenty days after injection, the calf died and was examined postmortem.

Autopsy: Animal greatly emaciated. Mediastinal glands greatly enlarged, edematous, and congested. Lung intensely congested; the anterior lobes are in a state of collapse, and show numerous hemorrhages under the pleura; sprinkled over the surface are numerous minute necrotic areas; on section the lung has a finely granular appearance, apparently a miliary tuberculosis of the entire organ; bronchial tubes show some slight congestion, and the smaller tubes contain a small amount of viscid mucus. Liver—Greatly swollen, edges rounded; the centers of the lobules appear as pale, yellowish gray points of irregular outline. Portal lymph glands pale but very edematous. Spleen—Enlarged and softened; trabeculae and Malpighian corpuscles distinct. Kidneys—Redder than usual, and show a sprinkling of white areas, few in number. Mesenteric glands edematous and congested. The glands at the brim of pelvis and just inside of the anterior portion of thorax are apparently normal. Throat glands edematous.

Microscopic examination: Lung—The lung tissue examined in section was infiltrated with cells, and there were a number of miliary tubercles scattered throughout it, all of which contained numerous tubercle bacilli. Liver—No distinct tubercle formation was observed, but a number of well-stained tubercle bacilli were seen in various portions of the section, usually in small clumps. The liver showed rather extensive fatty changes. Kidneys—Marked parenchymatous degeneration; no tubercle formation, though a few tubercle



Lung hog 483. Subcutaneous inoculation with pure culture bovine tuberculosis No. 81.

Liver from 183, culture taken on inoculation with pure culture *Leishmania tuberculoidea* No. 3.





Spleen hog 483. Subcutaneous inoculation with pure culture bovine tuberculosis No. 81.



Calf 286. Subcutaneous inoculation with pure culture human tuberculosis. No. C4.

bacilli were found in smears. Spleen—No sharply defined tubercles were seen, although there were some rather large areas of coagulation necrosis in which were found some giant cells and a large number of tubercle bacilli. Mediastinal gland; a very large number of well-stained tubercle bacilli were seen throughout the section; in some places there was a beginning necrosis of the cellular tissue and here the tubercle bacilli were especially abundant. Mesenteric gland—The portions seen in section were apparently normal, although a very few tubercle bacilli were found in smears from this gland. A guinea pig inoculated with a bit of lung tissue from calf No. 264 died of generalized tuberculosis.

There can be no doubt as to the result of this experiment. The human culture used for intravenous injection produced a severe generalized tuberculosis and was evidently directly responsible for the death of the calf. It is instructive to compare this autopsy with that of calf No. 260, inoculated with bovine III culture.

Record of calf No. 265.—Age, about 5 months. Tested with tuberculin before inoculation without reaction. August 9, 1902, injected 5½ c. c. of a suspension of human tubercle culture D T into right jugular vein. Began to lose in condition on August 22, 1902, but did not seem to be seriously ill until August 30, when the respiration had become very much accelerated and the animal appeared to be failing rapidly. The respiration became more rapid and labored and the emaciation and weakness gradually more marked. The calf was found dead September 8, 1902, thirty days after injection.

Autopsy: Lung very much congested and edematous; on section showed evidences of extensive broncho-pneumonia; other organs in very much the same condition as described for calf No. 264.

Microscopic examination: Lung—Large areas are solidified; a few tubercle bacilli were found in smears. Liver has undergone extensive degenerative changes; no tubercle bacilli could be found, but great numbers of a large bacillus which did not stain by Gabbett's method were found in the blood vessels. Spleen—No tubercle bacilli could be found, but there were enormous numbers of bacilli of the kind found in liver. Kidney—No tubercle bacilli could be found; the sections showed extensive cloudy swelling and the blood vessels were filled with the same large organism which was found in liver and spleen. Mediastinal gland—Smears showed fairly numerous tubercle bacilli and in the section many of the large bacilli previously mentioned were seen. A guinea pig inoculated subcutaneously with a bit of lung from calf No. 265 died of generalized tuberculosis.

Although at the autopsy the lesions gave every indication that the animal died of a severe generalized tuberculosis quite similar to the disease to which calf No. 264 succumbed, we are led to doubt this as a result of the microscopic examination. No tubercle bacilli could be

found in any of the organs with the exception of the lungs and mediastinal gland. In addition, the kidneys, spleen, and liver contained enormous numbers of an unidentified bacillus which was not acid fast. Under these circumstances the probability of a secondary infection seems very great, and the tuberculosis injection can not be considered as having produced, unaided, the lesions found at the autopsy. Unfortunately, this secondary infection was not suspected until the sections were examined, and we were therefore unable to study cultures of the organism associated with it.

Record of calf No. 274.—About 7 months old; weight, 230 pounds. Tested with tuberculin prior to inoculation and did not react. On September 15, 1902, 5 c. c. of a suspension of human tubercle culture C No. 4 was injected into right jugular vein. The calf remained well until September 24, 1902, when its respiration was accelerated. Beginning on this date it lost rapidly in condition, became emaciated, lost appetite, and respiration became labored. On October 2, 1902, the animal died and was examined postmortem.

Autopsy: Animal greatly emaciated; the pulmonary pleura was roughened and some portions presented small circular elevations the size of a pinhead. The lung tissue had a granular appearance on section; the dependent portions of the anterior lobes were considerably congested. Liver and kidneys congested. Some of the mediastinal glands congested.

Microscopic examination: Lung—Sections show a great number of miliary tubercles, all of which contain large numbers of tubercle bacilli. Liver—Many of the liver cells are undergoing a fatty degeneration; they are granular, and many have lost their nuclei; no distinct tubercles were found, although a number of clumps of tubercle bacilli, as well as scattered separate tubercle bacilli, well stained, were distributed throughout the organ. Spleen—Section shows a number of irregular areas of necrosis which contain large well-stained tubercle bacilli. Mediastinal gland—Some necrotic foci, which contain many large tubercle bacilli. Two guinea pigs inoculated, respectively, with bits of lung and spleen died of generalized tuberculosis.

From the foregoing record it is apparent that calf No. 274 died of a generalized tuberculosis which was brought about by the intravenous injection of human culture C No. 4. The result in this case may also be instructively compared with the results obtained in calves Nos. 260 and 264.

Record of calf No. 260.—Age, 5 months. Tested with tuberculin without reaction. July 19, 1902, 20 c. c. of a suspension in beef broth of bovine culture III was injected into the jugular vein. On July 30 the animal was spiritless, the appetite poor, and respiration accelerated. Beginning on this date the calf lost rapidly in condition, the respiratory disturbance became more marked, and the

appetite was lost completely. The animal was found dead on the morning of August 6, 1902.

Autopsy: Postmortem decomposition had progressed so far that it was difficult to make a satisfactory examination. Lungs almost completely solidified; on section they had a granular appearance. Liver had undergone considerable postmortem changes, but did not appear to be diseased. Spleen, kidneys, and lymph glands, with the exception of the mediastinal, appeared to be free from disease.

Microscopic examination: Lung—Smear preparations from this organ showed very many tubercle bacilli. The mediastinal gland also exhibited in smear preparations a considerable number of tubercle bacilli. Sections from the kidney showed neither tubercle formation nor tubercle bacilli, but considerable parenchymatous nephritis was present.

TABLE IV.—*Intravenous inoculations of calves.*

Material used.	Dose.	Number of animal.	Age of animal.	Date of inoculation.	Result of inoculation.
	c. c.				
Human culture F T	5	Calf No. 270 <i>a</i> ..	1 year...	Sept. 16, 1902	Recovered.
Human culture F L	5	Calf No. 275 <i>b</i> ..	9 mos....	do.....	Killed Nov. 3, 1902.
Human culture S E No. 3	5	Calf No. 272 <i>c</i> ..	8 mos....	Sept. 15, 1902	Recovered.
Human culture G D	5	Calf No. 271 <i>d</i> ..	8 mos....	Sept. 16, 1902	In moribund condition Nov. 26, 1902; killed.
Human culture 12124	5	Calf No. 289 <i>e</i> ..	6 mos....	Oct. 14, 1902	Killed Feb. 12, 1903.
Human culture C No. 1	5	Calf No. 273 <i>f</i> ..	8 mos....	Sept. 15, 1902	Recovered.
Human culture E T	5½	Calf No. 284 <i>g</i> ..	5 mos....	Aug. 9, 1902	Died Aug. 29, 1902.
Human culture D T	5½	Calf No. 265 <i>h</i> ..	5 mos....	do.....	Died Sept. 8, 1902.
Human culture C No. 4	5	Calf No. 274 <i>i</i> ..	7 mos....	Sept. 15, 1902	Died Oct. 2, 1902.
Bovine culture III	20	Calf No. 280 <i>k</i> ..	5 mos....	July 19, 1902	Died Aug. 6 1902.

The following footnotes show the condition of the calves after death:

a After recovery from inoculation with human virus received bovine culture subcutaneously. No lesions at autopsy.

b Lesions found at autopsy were apparently not progressive.

c After recovery received subcutaneous inoculation of bovine culture. At autopsy lesions found in lung, but not severe.

d Lesions of tuberculosis not sufficient to account for condition at time animal was killed.

e Necrotic areas in lungs. Tuberculous lesions not sufficient to account for poor condition when killed.

f After recovery received subcutaneous inoculation of bovine culture. When killed later, found tuberculous lesions; probably due to bovine culture.

g Postmortem showed a severe generalized tuberculosis.

h Lesions of generalized tuberculosis. The microscope disclosed a contaminating organism, and fatal result may have been partly due to that cause.

i The postmortem examination disclosed a generalized tuberculosis.

k Tuberculosis involving lungs and some lymph glands.

SUBCUTANEOUS INJECTIONS.

Record of calf No. 250.—About one year old; tested with tuberculin without reaction. April 12, 1902, a piece of tuberculous human lung tissue having a volume of one-half cubic inch was

introduced beneath the skin, back of left shoulder of this calf; a piece of thickened tuberculous intestine having a volume of about one-half cubic inch was introduced in like manner back of right shoulder. The diseased lung and intestine were derived from the same case of tuberculosis from which culture C No. 4 was obtained. On May 14, 1902, there was no lesion on the right side at seat of inoculation, but on the left there was a tumor about 3 by 3 inches in area. It had a soft center and had been discharging. The general condition of the animal was poor. As the animal did not improve, it was tested with tuberculin on June 19, 1902, and gave a good reaction. On September 10, 1902, it again gave a partial reaction to tuberculin. On October 1, 1902, the calf was killed and examined postmortem.

Autopsy: At seat of inoculation on left side there was a group of small abscesses in the skin; at seat of inoculation on right side a small subcutaneous tumor with walls of connective tissue streaked with hemorrhagic lines. The contents of the tumor consisted of broken-down necrotic material. The superficial glands in front and back of shoulders and in the flank contained numerous necrotic foci; on the pleuræ of the lung and chest wall were numerous pale-red excrescences, particularly plentiful on the right side, in the dorsal region, and on the posterior border of the principal lobe. Similar growths were attached to the diaphragm; these growths extended about one-fourth to one-third of an inch above the surface of the diaphragm and appeared as isolated, almost circular, elevations about one-half inch in diameter, or as patches made up of numerous similar growths which had coalesced and which varied from one to four inches in diameter. No lesions were found in the lung tissue or in the mediastinal glands.

Microscopic examination: Flank gland—Caseous material from this gland, in which was a considerable amount of lime salts, contained large numbers of tubercle bacilli. Shoulder gland—This gland, which had a caseous center containing a considerable amount of lime salts, also exhibited many tubercle bacilli in cover-glass preparations. Pulmonary excrescences—The section showed a large amount of newly formed connective tissue, many lymphoid cells, and many small blood vessels; there was no evidence of necrotic change; a not inconsiderable number of tubercle bacilli were found.

DESCRIPTION OF PLATE XVI.

Sections showing distribution of tubercle bacilli in organs of calf 286, inoculated subcutaneously with C No. 4, human culture. Stained with hematoxylin and carbol-fuchsin. Magnified 1,450 diameters.

Fig. 1.—Section of lung.

Fig. 2.—Section of spleen.

Drawing by W. S. D. Haines.



Liver calf 238. Subcutaneous inoculation with pure culture human tuberculosis. No. C 1.





Fig. 1.



Fig. 2.

Diaphragmatic excrescence—The appearance was very similar to that of the pulmonary excrescences, except that the process was not so far advanced, there being a less amount of fibrous tissue and more of the cellular elements; a few giant cells and a very few tubercle bacilli could be seen in different parts of the sections. Guinea pigs inoculated, respectively, with bits of the flank gland, pulmonary excrescence, and diaphragmatic excrescence all died of generalized tuberculosis.

By this inoculation we have produced a tuberculosis which though not fatal, was distinctly progressive in character and we therefore consider this case as one in which we have successfully infected a calf with human tuberculosis. Comparison between the record of this calf and the records of calves Nos. 286 and 274 shows the difference between the result of inoculation with tissues on the one hand and pure cultures on the other.

Record of calf No. 286.—About 6 months old. Tested with tuberculin before inoculation; did not react. On October 13, 1902, this animal was injected subcutaneously on the right side of neck, directly in front of shoulder, with 5 c. c. of a suspension of human tubercle culture C No. 4. On October 23, 1902, this calf had a swelling about 3 by 3 inches in area at seat of injection, and the adjacent prescapular gland was much enlarged. On October 27, 1902, the swelling persisted and the animal was evidently losing in condition. Appetite became very poor and the weakness gradually more pronounced. There seemed to be no disturbance of respiration during the early part of its illness, but on November 14, 1902, the breathing was labored. On this date the calf was unable to stand alone and in a dying condition, and was killed and examined postmortem.

Autopsy: The animal was extremely emaciated; at seat of injection the skin was indurated over an area about 4 inches square; under this induration the gland in front of shoulder was 4 by 3 inches in size. Axillary gland on side of injection was normal; flank gland on same side was normal. Lungs—The entire lungs with the exception of the dorsal portions of the principal lobes were intensely reddened and sprinkled throughout with minute tubercles. Liver normal in color, and sprinkled with numerous small necrotic areas, apparently tuberculous in character, varying in size from mere points to one-eighth inch in diameter. Spleen enlarged and filled with small, round, firm, white nodules, the size of squirrel shot, which are easily picked out of organ. Sprinkled over the omentum were a number of small pearl-gray nodules with reddish centers, probably tubercles. Glandular system—Prescapular gland (immediately beneath point of injection) greatly enlarged; nodular but not caseous; entire gland quite firm. Pharyngeal

glands considerably enlarged; a number of small, firm, yellowish nodules in the body of the gland. Mediastinal glands considerably enlarged; the surface was rough; there were no caseous areas. Pubic glands about normal in size, but contained one or two small areas that looked suspiciously like tuberculous foci. Mesenteric glands apparently slightly enlarged. Shoulder gland normal in size and appearance. Flank gland normal. (See Pls. XIII, XIV, XV, and XVI.)

Microscopic examination: Lung—A number of well-defined miliary tubercles were visible in the sections. The central portion of most of the tubercles had undergone a coagulation necrosis and they were in some instances homogeneous and structureless and in others consisted of a mass of nuclear fragments which stained with hematoxylin; all of the tubercles contained a considerable number of rather large tubercle bacilli. Liver—Several large tubercles were found in the sections; the central portions of them were necrotic and they contained a number of well-stained tubercle bacilli. Spleen—This organ contained a number of rather large, well-defined tubercles, most of which had necrotic centers and contained a number of tubercle bacilli, well stained, rather long, many of them beaded. Kidney—A smear from one of the tubercles showed quite numerous tubercle bacilli. Prescapular gland—Large areas of coagulation necrosis, not sharply defined; many well-stained tubercle bacilli were scattered throughout the tissue, more numerous in some places than others. Gland just inside thorax—Some large areas of necrosis and many well-stained tubercle bacilli were found. Pharyngeal gland—A few large, poorly defined areas which were undergoing degenerative changes; a considerable number of well-stained tubercle bacilli could be seen in the affected portions of the tissue. Shoulder gland—No tuberculosis. Flank gland—No tuberculosis. Mediastinal gland—Many tubercle bacilli found. Intestines—No tuberculosis. Suprarenal body—No tuberculosis. Pubic gland—Tubercle bacilli fairly numerous.

From the record of this experiment it will be seen that we have in this instance a generalized tuberculosis in a calf produced by subcutaneous injection of a culture of human tuberculosis. This record should be carefully compared with that of calf No. 284, which was injected subcutaneously with a culture of bovine origin.

Record of heifer calf No. 288.—October 2, 1902; a small animal in fairly good condition, about 6 months old. October 11, 1902, tested with tuberculin without reaction. Injected October 13 subcutaneously on the right side of neck directly in front of shoulder with 5 c. c. of a suspension of human tubercle culture E T. This animal developed an extensive swelling 4 by 5 inches in diameter at the seat of injection. There was, however, very little evidence

of general illness. On December 19, 1902, it was killed and examined postmortem.

Autopsy: A tumor 5 by 3 inches at seat of injection; the central portion of this tumor was entirely broken down and filled with a thin, partly cloudy, serous fluid; the walls of the cavity were quite thick and the inner portion was necrotic. Prescapular gland—About normal in size; upon section several yellowish nodules were found. Mediastinal glands—Enlarged; upon section areas of necrosis which contained a considerable amount of lime salts were seen in cortical portion. Lungs—A large number of round, grayish nodules varying from 3 to 8 mm. in diameter were sprinkled over all the lobes of both lungs; these nodules were hard and shot-like, and projected slightly above the surface of the lung; upon section similar nodules were seen to be scattered throughout the organ; the lung tissue, aside from these nodules, showed no lesions. Liver—The color of the main body of the organ was normal; there were, however, scattered over its entire surface a number of round, sharply defined, slightly elevated white areas which varied from 3 to 8 mm. in diameter; upon section similar areas were seen throughout the organ; these nodules were hard and could be distinctly felt projecting above the surface of the liver. Spleen—Normal in size and general appearance; upon section a few firm, round, whitish areas were found, closely resembling the bodies found in spleen of calf No. 286. Kidney—Normal. Intestines—Normal. Mesenteric glands—Normal in size, but upon section a few yellowish areas containing lime salts were found. (See Pls. XVII, XVIII, and XIX.)

Microscopic examination: Lung—A number of large tubercles usually having a distinct surrounding wall of connective tissue, numerous giant cells and necrosis of the center of the tubercles were seen; a very few tubercle bacilli were found. Liver—Tissue generally is in a fair condition; found two rather large areas of circumscribed coagulation necrosis, one of which contained a giant cell; no tubercle bacilli in sections; a few were found in smear preparations from this organ. Spleen—Several tubercles in one section and in one a giant cell; no tubercle bacilli in the section, but a very few in a smear preparation. Kidney—Extensive parenchymatous nephritis with some increase of connective tissue; no tubercles and no tubercle bacilli found. Mesenteric gland—Several large foci of necrosis containing many large giant cells and a very few tubercle bacilli. Point of inoculation—A few tubercle bacilli were noted in smear preparations. Prescapular gland—A few well-stained tubercle bacilli were found in smear preparations.

It is evident that the subcutaneous inoculation of calf No. 288 with human tubercle bacilli brought about a generalized tuberculosis in the animal.

Record of calf No. 285.—October, 1902, red-and-brown heifer about 13 months old, tested with tuberculin without reaction. January 24, 1903, injected subcutaneously in front of right shoulder with 5 c. c. of a suspension of human tubercle culture E T. February 3, 1903, had a lesion at seat of injection which was continuous with the prescapular gland. The latter was about 2 by 5 by 3 inches in size. The general condition of the animal was fairly good. February 13, 1903, prescapular gland and tumor at seat of injection had coalesced, forming a hard enlargement about 4 by 9 by 3 inches in size; general condition poor. February 26, 1903, tumor at seat of injection and nearest prescapular gland have a combined volume of about 6 by 10 by 3½ inches; this enlargement is very hard; general condition is poor; respiration seems to be normal. April 28, 1903, killed and examined postmortem.

Autopsy: Animal in fairly good condition, not fat; at seat of injection in front of right shoulder the lymph gland was about 6 by 5 by 4 inches in size and very firm; a number of small calcareous nodules in the mediastinal glands; the lungs and spleen were dotted here and there with small tubercles.

This animal was inoculated as a control on calf No. 288, and, as will be seen from the record, developed a generalized tuberculosis, which was not so severe, however, as that produced in calf No. 288. Calf No. 285 was about 7 months older than calf No. 288.

Record of calf No. 287.—About 6 months old. October 11, 1902, tested with tuberculin without reaction. October 13, 1902, injected subcutaneously on right side of neck directly in front of shoulder with 5 c. c. of a suspension of human tubercle culture D T. On October 23, 1902, this animal presented a large swelling at the point of injection, and the prescapular gland which was directly beneath this point was enlarged. There were practically no symptoms other than the local lesions as a result of the injection. On December 19, 1902, this calf was killed and examined postmortem.

Autopsy: A large tumor 5 by 3 inches at seat of injection; this tumor was hard, the central portion was necrotic but not softened. Prescapular gland about 3 by 1½ inches; the cortical portion contained tuberculous foci with considerable deposits of lime salts. Gland just inside thorax; about the size of a walnut; a large portion

DESCRIPTION OF PLATE XIX.

Reproduction of a smear and a section from tissues of calf No. 288 inoculated subcutaneously with human culture E T, indicating the distribution of bacilli. Stained with hematoxylin and carbol-fuchsin. Magnified 1,450 diameters.

Fig. 1.—Smear made from lung.

Fig. 2.—Section from a mesenteric gland.

Drawing by W. S. D. Haines.



Lung Calf 288. Subcutaneous inoculation with pure culture human tuberculosis No. E. T.



LIVER, Call 288. Subcutaneous inoculation with pure culture human tuberculosis No. E. T.



Fig. 1.



Fig. 2.

of the gland was necrotic and contained abundant lime salts. This animal was otherwise normal.

Microscopic examination: At point of injection numerous rather large, well-stained tubercle bacilli were found. Smear preparations from prescapular gland contained a few well-stained tubercle bacilli. Gland just inside thorax contained a very few tubercle bacilli.

It is evident that culture D T is distinctly lower in pathogenic power for cattle than either culture E T or C No. 4. It appeared, however, to be possessed of nearly if not quite as great pathogenic power as the rather feeble bovine III culture, and after subcutaneous injection succeeded in invading the lymph glands adjacent to the seat of injection.

Record of calf No. 221.—About 18 months old; gave negative result to tuberculin test. Injected subcutaneously in front of right shoulder with 6½ c. c. of a dilute suspension of human culture G D September 23, 1902. The calf showed no signs of illness as a result of the inoculation. Was tested with tuberculin in June, 1903, and gave no reaction. In November, 1903, the animal being in excellent physical condition, was exposed to natural infection with bovine tuberculosis by being placed in the stall with tuberculous cattle. No symptoms of illness resulted, although several other animals placed under similar conditions contracted tuberculosis.

The calf was killed August 17, 1904, and examined postmortem. No lesions of any kind were found. This experiment was therefore entirely negative in so far as the injection of the calf with human tuberculosis is concerned. The calf evidently possessed considerable resisting power to natural infection. The probability of this immunity having been conferred by the injection of culture G D will be discussed in Part III of this bulletin.

Record of calf No. 290.—About 6 months old; tested with tuberculin without reaction. Injected subcutaneously in front of right shoulder on October 14, 1902, with 5 c. c. of a suspension of human culture F T. No marked disturbance of the health of the animal as a result of the inoculation could be observed. A tumor developed at the point of injection and persisted until June, 1903, when the animal was tested with tuberculin and gave a slight reaction. On July 23, 1903, the calf was killed. The only tuberculous lesions which could be found at autopsy were situated in the subcutaneous tissues at the point of injection.

Record of calf No. 291.—About 6 months old; no reaction from tuberculin test. On October 14, 1902, injected subcutaneously in front of right shoulder with 5 c. c. of a suspension made from human tubercle culture F L. The record of this animal is quite similar to that of calf No. 290. A tumor formed at the point of inoculation, but

the health of the calf remained good. When tested with tuberculin on June 30, 1903, a slight reaction was obtained. The calf was killed on July 23 and examined postmortem. The only lesions found were situated in the subcutaneous tissues at the point of injection.

Human cultures F T and F L evidently did not possess sufficient pathogenic power to cause the infection of these two calves after subcutaneous injection.

Record of calf No. 284.—Red-and-white heifer calf, about 13 months old. Tested with tuberculin December 13, 1902, without reaction. January 24, 1903, injected subcutaneously in front of right shoulder with 5 c. c. of a suspension of bovine tubercle culture C No. 81. The injection was followed by the usual local swelling and enlargement of the prescapular gland. The animal in the course of two months failed somewhat in general condition, the respiration became slightly accelerated, and the local lesions persisted. On April 10, 1903, the general condition of the calf was poor and the animal was killed and examined postmortem.

Autopsy: At seat of injection on right side of neck there was an abscess about 3 by 4½ by 2 inches in size; below the abscess the prescapular gland was greatly enlarged and very firm. Lungs were sprinkled throughout with tubercles, which were more numerous in the anterior portions; these tubercles presented a minute pearl-gray center surrounded by a zone of pale-pink edematous tissue. Liver contained a few necrotic foci, which were visible on the surface. Mediastinal glands enlarged. Spleen contained tuberculous foci. Intestines contained numerous worm nodules; no mesenteric disease; a few tubercles, beginning pearly disease, on the omentum over paunch, and a few small tubercles were also found on the costal pleura. (See Pls. XXII and XXIII.)

Microscopic examination: Lung—The sections presented tubercles of varying size which contained giant cells and a few tubercle bacilli. Spleen showed extensive tubercle formation with giant cells and scattered tubercle bacilli. The sections from the liver and kidney showed no lesions.

Record of calf No. 223.—Tested with tuberculin without reaction. Age about two and one-half months. On November 2, 1901, this animal was injected subcutaneously with 10 c. c. of a suspension of bovine culture III (Smith). On January 21, 1902, and April 18, 1902, reactions after tuberculin injections were noted. On October 2, when the animal was killed, its general condition was excellent. At the seat of injection there were embedded small abscesses containing a soft, cheesy material. The shoulder glands on the side of infection, both deep and superficial, were enlarged and sprinkled with necrotic foci. The mediastinal glands contained numerous necrotic foci. No other lesions of any kind were present.

This animal showed, therefore, after eleven months, very much less evidence of tuberculosis than was found after six weeks in calves which received subcutaneous injections of material from tubercle cultures isolated from children.

TABLE V.—*Subcutaneous inoculations of calves.*

Material used.	Dose.	Number of animal.	Age of animal.	Date of inoculation.	Result of inoculation.
	c. c.				
Tuberculous human lung and intestine.	1 piece of each.	Calf No. 250 ^a	1 year...	Apr. 12, 1902	Killed Oct. 1, 1902.
Human culture C No. 4.	5	Calf No. 246 ^b	6 mos...	Oct. 13, 1902	Killed Nov. 14, 1902, when in dying condition.
Human culture E T...	5	Calf No. 288 ^c	do do do do	do do do do	Killed Dec. 19, 1902, in fair condition.
Do	5	Calf No. 285 ^d	13 mos...	Jan. 24, 1903	Killed Apr. 28, 1903, condition poor.
Human culture D T...	5	Calf No. 287 ^e	6 mos...	Oct. 13, 1902	Killed Dec. 19, 1902, condition fair.
Human culture G D...	6½	Calf No. 221 ^f	18 mos...	Sept. 23, 1902	Still living, condition excellent.
Human culture F T...	5	Calf No. 290 ^g	6 mos...	Oct. 11, 1902	Killed July 23, 1903, after tuberculin reaction.
Human culture F L...	5	Calf No. 291 ^g	do do do do	do do do do	Do.
Bovine culture III	10	Calf No. 223 ^h	2½ mos...	Nov. 2, 1901	Killed Oct. 2, 1902, condition excellent.
Tissue from monkey No. 1, inoculated with bovine III.	Small piece.	Calf No. 226 ⁱ	1 mo...	do do do do	Killed Oct. 6, 1902, condition poor.
Bovine culture C No. 81	5	Calf No. 284 ^j	13 mos...	Jan. 24, 1903	Killed Apr. 10, 1903, condition poor.

The following footnotes show the condition of the calves after death:

^a Tuberculosis of superficial lymph glands, and of the pulmonary and diaphragmatic pleuræ.

^b The autopsy disclosed a severe generalized tuberculosis.

^c Autopsy revealed lesions of a generalized tuberculosis.

^d Generalized tuberculosis. Not so extensive as in case of calf No. 288.

^e Glands adjacent to point of inoculation were tuberculous.

^f Animal tested with tuberculin June 30, 1903, and did not react.

^g No lesions except abscess at point of inoculation.

^h Abscesses at point of inoculation. Shoulder glands on same side and mediastinal glands tuberculous. No other lesions.

ⁱ Tuberculosis of lungs, spleen, mediastinal, axillary and shoulder glands.

^j Generalized tuberculosis.

Record of calf No. 226.—About 1 month old. Given tuberculin test without reaction. November 2, 1901, injected subcutaneously back of left shoulder with tuberculous tissue from monkey No. 1, which died as a result of inoculation with bovine III culture. The calf was tested with tuberculin on the following dates, each time giving a good reaction—January 21, February 27, April 18, and June 26, 1902. Killed October 6, 1902, and examined postmortem.

Autopsy: At seat of injection a group of minute necrotic foci surrounded by thick connective tissue walls, the usual injection lesion produced by bovine tubercle germs. There were numerous minute foci of tuberculosis in the mediastinal glands; entire lung sprinkled with small tuberculous foci; the shoulder and axillary glands were tuberculous; numerous nodules of disease in the spleen; other organs and glands not affected. Two guinea pigs inoculated subcutaneously with a diseased fragment from the spleen of this calf died of generalized tuberculosis.

The widespread lesions found in this calf would seem to indicate an increase in the virulence of bovine III culture by passage through the monkey, inasmuch as a pure culture of the same organism failed to produce generalized tuberculosis in calf No. 223. Without more experimental evidence upon this point, however, we can not regard such an increase in virulence as definitely established.

MISCELLANEOUS ANIMAL EXPERIMENTS.

Record of calf No. 254.—Age, about 7 months. February 27, 1902, tested with tuberculin without reaction. March 7, 1902, injected intraabdominally with 5 c.c. of human sputum containing very many tubercle bacilli; also many other bacteria, staphylococci, etc. Within three weeks after injection the animal appeared to be unwell, appetite was poor, and there was considerable tenderness surrounding the point of injection. On May 1, 1902, the animal reacted to a tuberculin test, and declined in condition from that time on, and was killed on September 23, 1902.

Autopsy: On opening the abdominal cavity the left wall was found to be thickly studded with minute white elevations, varying in size from mere points to about one-eighth inch. Among these elevations were a few which had necrotic centers; similar but less numerous lesions on the omentum, the surface of the rumen, the abdominal and thoracic surfaces of the diaphragm, and on the mesentery; the lesions had very much the appearance of the beginning of pearl disease (see Pl. XX). A few necrotic foci were found in the tissue of the liver near the convex surface. The liver and the stomachs were bound to the diaphragm by means of firm bands of white connective tissue, which were studded with white elevations of the kind already described. The surface of the spleen was marked with similar elevations somewhat larger than in other regions. One cheesy nodule, about 1 inch in diameter, in the abdominal cavity near the duodenum; this nodule on section discharged a thick, granular pus. The walls of the abscess were moderately thick. Lung—The entire cephalic, two-thirds of the ventral, and one-fourth of the principal lobes on both sides were solidified, and

of a pale-red color; the solidified areas were sprinkled with nodules, varying in size from one-sixteenth to one-half inch, which on section were found to be dilatations of the bronchial tubes filled with thick viscid mucus. The abdominal and thoracic glands were all enlarged and edematous, but showed no other lesions.

Guinea pigs inoculated with fragments of lung and of a nodule on the peritoneum died of generalized tuberculosis. Calf No. 276, injected with material from the peritoneum of calf No. 254, did not contract tuberculosis.

Calf No. 254 evidently contracted tuberculosis as a result of the injection with human sputum. The disease was not virulent in character, but was plainly progressive. The failure of calf No. 276 to contract the disease when injected with tuberculous tissue from calf No. 254 may have been due to the fact that it received the tubercle bacilli free from other organisms, whereas calf No. 254, which was injected with sputum, received a mixture of tubercle bacilli with various other microorganisms. In view of the fact that in calf No. 254 the tubercle bacilli invaded the lung and the costal pleura after intraabdominal injection, we consider this as a successful transference of human tuberculosis to cattle, although the human tubercle bacilli were aided possibly in their struggle with the resisting powers of the calf by other microorganisms.

Record of steer No. 242.—About 20 months old. The animal was drenched with bovine tuberculous material, obtained from cases of spontaneous tuberculosis in cattle, on January 10, 11, 13, and 21, 1902, and on February 17, 18, and 26 of the same year. Tested with tuberculin a positive reaction was obtained. On October 6, about 9 months after the first drenching, this animal was killed. A few small foci of a tuberculous character were found in the mediastinal and in the lymph glands at the entrance of thorax; otherwise there was no evidence of tuberculosis.

Record of heifer No. 237.—About 2½ years old. November 7, 1901, tested with tuberculin without reaction. This animal was then fed or drenched with tuberculosis material at varying intervals during a period of 6 months, as follows: November 22, 1901, fed with bran mixed with some tuberculous nodules from a human lung. December 23, 1901, a suspension was made in water of several tuberculous nodules from a human liver; a pint of this material was introduced into the stomach of the calf. December 26, 1901, drenched with a pint of a watery suspension of human tuberculous material, together with some serous fluid from the same case of human tuberculosis. January 8, 1902, drenched with a suspension of a tuberculous human liver. February 11, 1902, a suspension of tuberculous human lung in about 1 gallon of water,

with about 50 c. c. of tuberculous human sputum, from adults suffering from pulmonary tuberculosis was introduced into the animal's stomach through a rubber tube. February 27, 1902, a tuberculin test showed no reaction. On March 4, 1902, the calf was drenched with a watery suspension of a portion of a tuberculous human lung. March 7, 1902, about 100 c. c. of tuberculous human sputum was fed to the calf through a rubber tube. About half of the sputum was derived from the same source as that used for the injection of calf No. 254; the other half was obtained from the case that furnished the material from which culture F L was obtained. Both contained large numbers of tubercle bacilli. April 5, 1902, a tuberculin test failed to give a reaction. On April 12, 1902, the heifer was drenched twice with tuberculous material of human origin; the first time it received a suspension of 8 to 10 cubic inches of a tuberculous human lung in water; at the second drenching, an hour later, it received a suspension of tuberculous intestines and mesenteric glands from a child, the latter material being derived from the same source as was culture C No. 4, the culture proving quite virulent for calves when injected subcutaneously. On May 13, 1902, a considerable amount of human tuberculous material (consisting of portions of the lung, liver, spleen, and kidney from a case of generalized tuberculosis) suspended in water was fed to the animal. May 19, 1902, about 8 or 10 cubic inches of a tuberculous human lung and mesenteric glands were cut into small fragments and mixed with water and fed to the calf. On June 26, 1902, tested with tuberculin without reaction.

The general condition of this animal remained excellent; it was killed on October 28, 1902, and the autopsy revealed no trace of tuberculosis. It must be said with regard to the material used for feeding the animal that none of it was proved to possess noticeable pathogenic virulence for cattle upon subcutaneous injection, with the exception of that marked C No. 4. Previous to receiving the virulent material, however, many feedings of a tuberculous virus of a low degree of virulence had been given, and there is a possibility that a certain amount of resistance to tuberculosis had been acquired in this way; in any case one feeding experiment of this character can not be considered as in any way decisive, the individual resistance of the animal being a quantity which must always be reckoned with.

Record of sheep No. 41.—January 29, 1902, tested with tuberculin without reaction. July 19, 1902, injected 10 c. c. of human tubercle culture No. 50 into right jugular vein. As a result of this injection the animal developed a severe respiratory disturbance and lost considerably in condition. At times it seemed to improve, but failed

again and gradually became very emaciated. On January 6, 1903, the sheep was killed and examined postmortem.

Autopsy: Lung—The pleura showed numerous patches of thickening which in many places looked like fibrinous neoplasms of a shreddy character, and which constituted in some cases adhesions between the costal and pulmonary pleuræ; the lung tissue was sprinkled with nodules of a necrotic tuberculous character varying in size from one-sixteenth to one-half inch. (See Pl. XXIV.) Mediastinal gland tuberculous; some white points in the liver, kidney, and spleen; the general appearance was that of a tuberculosis which had its origin in the lung, spreading from this organ and finally producing a generalized miliary tuberculosis.

TABLE VI.—*Miscellaneous animal experiments.*

Animal.	Material used.	Method of administration.	Age of animal.	Date of exposure to infection.	Result.
Calf No. 254 ^a ..	Tuberculous human sputum.	Intraabdominal (5 c. c.).	7 mos...	Mar. 7, 1902	Killed Sept. 23, 1902.
Heifer No. 237 ^b	Tuberculous human tissue and sputum.	By mouth....	2½ years.	Nov. 22, 1901	Killed Oct. 28, 1902.
Steer No. 242 ^c ..	Tuberculous bovine tissue.	do.....	20 mos..	Jan. 10, 1902	Killed Oct. 6, 1902.
Sheep No. 41 ^d ..	Human tubercle culture 50.	Intravenous (10 c. c.).	Old ewe.	July 19, 1902	Killed Jan. 6, 1903.

The following footnotes show the condition of the animals after death:

^a Tuberculosis of peritoneum, lungs, and pleuræ.

^b No tuberculosis.

^c A few small tuberculous foci in mediastinal and anterior thoracic glands. No other lesions.

^d Generalized tuberculosis.

As will be seen from the foregoing records, several drenching or feeding experiments with cattle were made both with human and bovine tuberculous material. At the time the animals were killed the human material had not caused any disease, while the bovine material had produced slight results. When we compare the disease produced by bovine III culture, which had been grown in the laboratory of the Bureau for a number of generations, with that produced by bovine culture C No. 81—the culture recently isolated—there seems to be almost as great a difference in virulence between the two as there is among the various cultures of human origin.

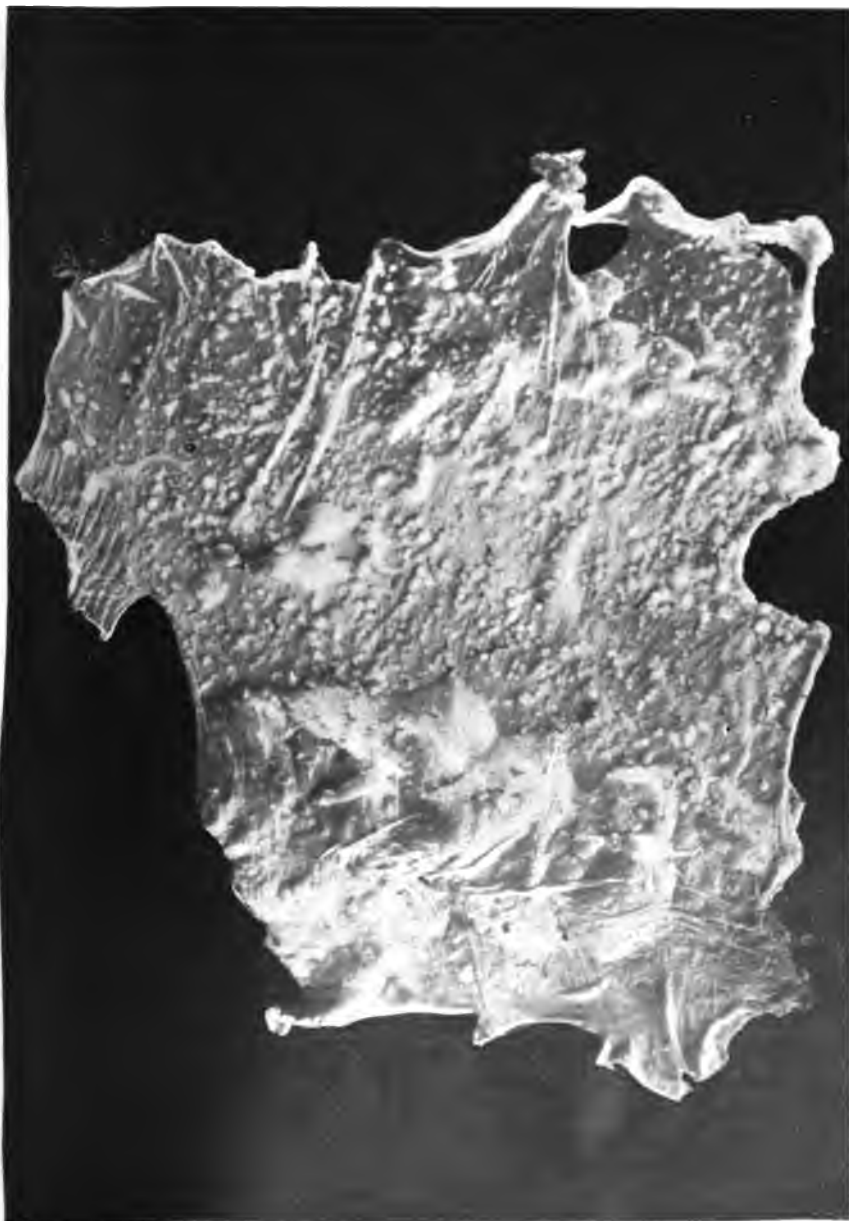
DISCUSSION OF THE CATTLE EXPERIMENTS.

We isolated in all nine fresh tubercle cultures from as many different cases of human tuberculosis. Five of these cultures were obtained from adults and four from children. One calf was injected intravenously with each of the cultures, but owing to the fact that the microscopic examination of the organs of calf No. 265, injected with human culture D T, revealed the presence of large numbers

of a microorganism differing from the tubercle bacillus, we will not take this case into account in determining the percentage of positive results. An examination of the record of calf No. 287, injected subcutaneously with the same culture—D T—indicates that this culture possesses distinct though rather feeble pathogenic power for cattle. If the record of calf No. 287 be compared with that of calf No. 223, injected subcutaneously with bovine culture III, it will be seen that, assuming the resisting powers of the two calves to be equal, human culture D T is nearly, if not quite, as virulent for calves upon subcutaneous injection as bovine culture III, and this bovine culture, upon intravenous injection, produced an infection of the lungs and lymphatic glands. Reasoning in this fashion, we are inclined to believe that human culture D T was the chief cause of the lesions found in calf No. 265, but owing to the element of uncertainty, which can not be overcome, this animal will not be considered among the intravenous injections.

Eight calves were injected intravenously with as many different cultures of tubercle bacilli of human origin, five being obtained from adults and three from children. Of the eight cultures, two, or 25 per cent, produced a fatal generalized tuberculosis. The two that produced fatal disease in calves were both derived from children; therefore two out of three of the cultures from children were quite as virulent for calves as the bovine tubercle bacillus.

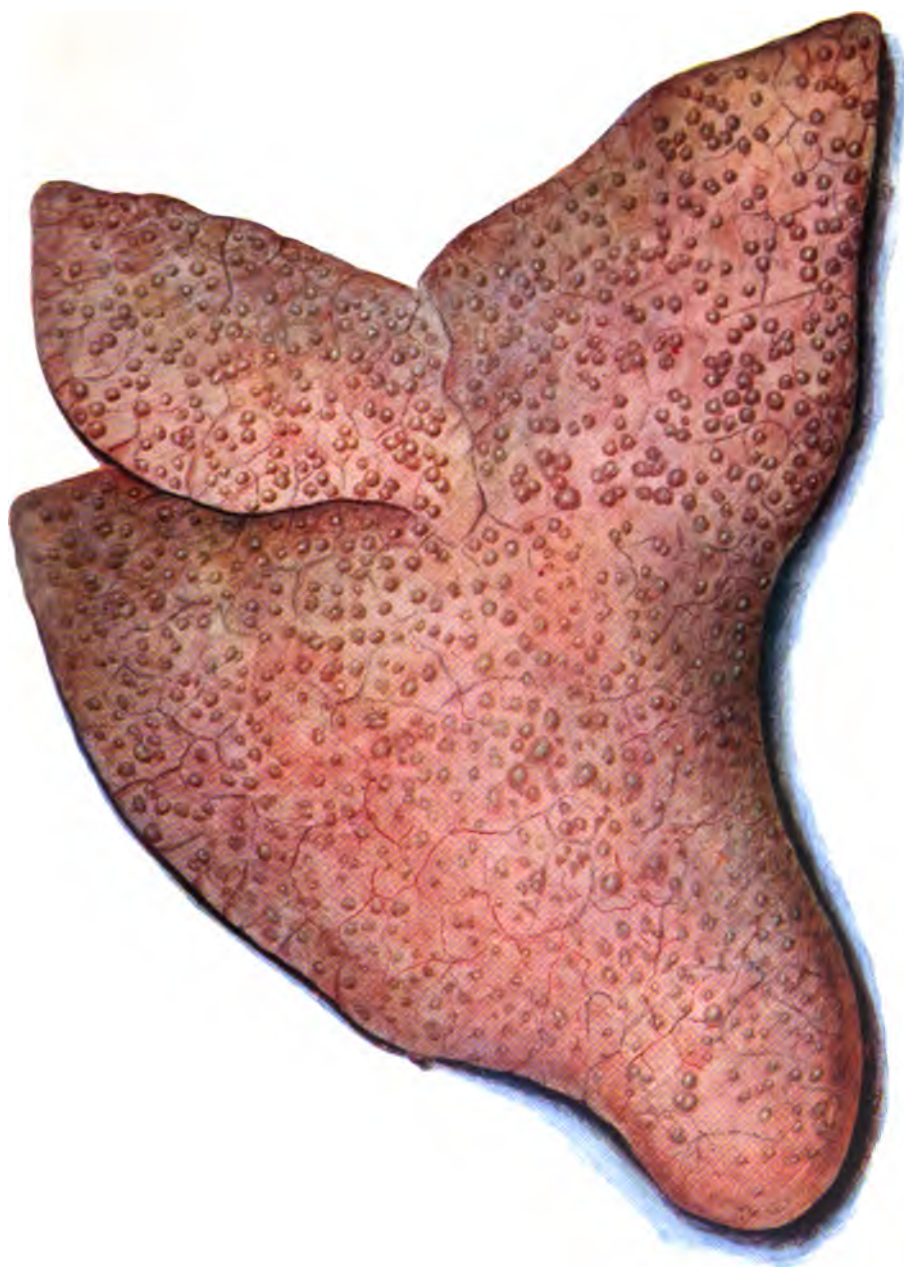
It was not thought necessary to inject calves subcutaneously with the cultures which gave little or no evidence of pathogenic properties when injected intravenously. Six of the most virulent human cultures were therefore selected for the subcutaneous injections. As indicated in Table V, seven calves were injected subcutaneously with the six cultures, and one calf (No. 250) was injected with human tuberculous tissue obtained from the same source as one of the cultures (C No. 4). Three of the six cultures used were derived from adults and three from children. The results of these injections may be summarized as follows: One culture failed to produce any lesion persisting for as long a period as 9 months; two produced a localized abscess at the point of injection; a fourth culture produced a local lesion and the disease extended to the neighboring lymph glands. The two remaining cultures brought about a generalized tuberculosis in the calves injected with them. Taking into account, then, the whole number of human cultures isolated, we find that two out of nine, or 22.2 per cent, produced a generalized tuberculosis after subcutaneous injection. A third culture, D T, must be considered as infectious for cattle, as the disease within 2 months from the time of injection extended from the point of inoculation to the adjacent prescapular gland, and through that or some other channel to the deeper gland just inside of the thorax. We can then revise



PERITONEUM FROM CALF No. 254, SHOWING THE LARGE NUMBER OF TUBERCLES PRODUCED BY THE INTRAPERITONEAL INJECTION OF HUMAN TUBERCULOUS SPUTUM.



NATURAL BOVINE TUBERCULOSIS IN LUNG OF COW.





the figures just given, since out of nine human cultures isolated, three, or 33½ per cent, produced tuberculosis in cattle after subcutaneous injection. These three virulent cultures were all obtained from children, so that out of four cultures derived from cases of generalized tuberculosis in children three were capable of bringing about infection in cattle.

It will be remembered that in the summary of the intravenous injections it was stated that two out of three of the cultures from children produced tuberculosis in calves, while after subcutaneous injection we state that three out of four produced infection. This discrepancy is due to the fact previously explained that a mixed infection appeared to have taken place in the animal injected intravenously with culture D T, and for this reason the injection with that culture was thrown out.

So far as our experiments upon cattle are concerned, therefore, we must conclude that tubercle bacilli of various degrees of virulence for cattle may be obtained from human sources—some quite as virulent as the tubercle bacilli known to be of bovine origin and others less so.

The results of our experiments also lead us to conclude that there is no essential difference between tubercle bacilli derived from bovine sources and those derived from man. In fact, we know of no character possessed by bovine tubercle bacilli which may not be possessed by tubercle bacilli of human origin. The two most virulent human tubercle cultures described in this bulletin can not be distinguished from the classical bovine type either with regard to their cultural characters or their pathogenic power for cattle and other animals.

Dr. Theobald Smith has been the chief advocate for a racial distinction between bovine and human tubercle bacilli, although he does not deny the infectiousness of bovine tubercle bacilli for man. On the contrary, he considers those cultures of human tubercle bacilli which correspond culturally and in respect to their pathogenic powers with the ordinary bovine tubercle bacillus as being originally of bovine origin.

While we believe firmly that tubercle bacilli of bovine origin may infect human beings, we can not accept the theory that tubercle bacilli derived from man are necessarily of bovine origin because they possess characters of the ordinary bovine bacillus. In other words, in regard to those cases of human tuberculosis from which bacilli virulent for cattle are obtained, it must be shown first of all that the individuals in question became infected through tuberculous meat or milk. The possibility of the infection having been derived from cattle always exists, but in our opinion the biological characters of the infecting organism are not sufficient to show that

meat or milk was the source of the disease, and in like manner a tubercle bacillus of low virulence obtained from cattle should be considered to be of bovine origin unless there is some evidence of infection from other sources. The fact that certain tubercle bacilli derived from man resemble the majority of bovine bacilli is to our mind evidence of the unity of the two races.

EXPERIMENTS UPON MONKEYS.

In addition to the investigations made to determine the extent to which tubercle bacilli of human origin are infectious for cattle, the intimately related question whether tubercle bacilli of bovine origin are infectious for man was approached as closely as possible by a series of experiments with monkeys.

It is a generally admitted zoological fact that man stands in closer relationship to the quadrumana than to other animals. With this view accepted, we may reasonably assume that apparently similar disease-producing microorganisms found in man and cattle, the identity of which has been questioned, are practically the same in their pathogenic significance if they produce identical affections in monkeys.

Of the monkeys used in our experiment one was a Cebus, two belonged to the genus Rhesus, and four were baboons. Two tubercle cultures were used, one—No. 50—of human origin, which had been under cultivation for a long time at the laboratory and was virulent for guinea pigs, and one bovine culture—III.

Four of the monkeys received injections of bovine tubercle culture; two received injections of human tubercle culture, and one was fed milk containing bovine tubercle bacilli. No cow could be found with a tuberculous udder which had become infected in the natural way at the time the feeding experiment was made, and so the milk was obtained from a cow whose udder was injected with culture bovine III. The milk from the udder-injected cow showed the presence of tubercle bacilli on microscopic examination, and on injection into guinea pigs caused fatal, generalized tuberculosis.

The monkeys were confined in large cages, each of which was supplied with perches and a partly closed sleeping compartment to which the animal could retire at will. The cages were placed in a one-roomed, properly heated, well-lighted and ventilated house, which was guarded during cold weather against sudden changes of temperature by a small vestibule with inner and outer doors. Both the cages and the house were specially constructed for this experiment and had not been used previously for any other purpose.

Record of monkey No. 1.—Female baboon, in excellent condition, tested with tuberculin without reaction, kept under observation about two weeks and showed no symptoms of disease; weight 8 pounds 9

ounces. September 12, 1901, injected subcutaneously, left side, about 1 inch below udder, with 1 c. c. tubercle culture bovine III.

A firm tumor at once developed at the seat of injection, which gradually increased in size, softened, broke open, and discharged a creamy, gray, pus-like substance, and formed, by October 4, a deep ulcer, 1 by $\frac{1}{2}$ inch in area, with a thickened, rounded, raised border. The skin about the ulcer became generally thickened and detached from the subcutaneous structures over a diameter of $2\frac{1}{2}$ inches. The monkey spent much time fingering and picking the wound, which was washed with weak solution of carbolic acid and covered with a thin layer of powdered chalk and alum. The axillary lymph gland on the side of injection increased greatly in size and was clearly visible as a tumor under the skin when the monkey's arm was drawn upward. On October 8 the ulcer at the seat of injection was almost circular, $1\frac{1}{2}$ inches diameter, and its surface was covered by a thin layer of thick, gray pus. The enlarged axillary gland measured 1 by $\frac{3}{4}$ by $\frac{1}{2}$ inch, and was firm and nodular to the touch. On October 12 the weight of the monkey was 7 pounds 15 ounces, and on October 26 this had fallen to 7 pounds.

The general condition of the monkey, beginning a few days after the injection until October 30, 1901, on which date she was chloroformed and examined postmortem, became gradually worse. On October 29 the following record was made: Monkey has been growing constantly weaker and now is so weak that she can barely sit with her body in an erect position. She is drowsy, keeps her eyes closed, and rests her head on her hands in a very human attitude, and refuses all nourishment excepting a little fruit. The next day, on which she was killed, she was noticeably weaker and practically in a dying condition.

Autopsy: At the seat of injection a large ulcerated area, about $1\frac{1}{2}$ inches in diameter. The pleural cavity contains a viscid, sero-fibrinous exudate, by means of which the costal and pulmonary pleuræ are bound together. The lung is thickly sprinkled with opaque, yellowish white areas, of a cheesy appearance, the diameter of which varies from 1 mm. to about 2 cm. The several lobes of the lung are adherent to each other and the lung tissue is firm and airless. Pericardium distended with clear, serosanguinous fluid. Heart—Near the apex of the left ventricle, in the muscle, is an opaque, white area about 2 mm. in diameter. Liver apparently enlarged and mottled with numerous opaque, white areas from 1 to 5 mm. in diameter. Spleen apparently enlarged and sprinkled with opaque, dirty-white areas, which have a cheesy appearance and vary in diameter from 1 mm. to 1 cm. Kidneys pale and studded with opaque, white areas about 1 mm. diameter. The mediastinal, axillary, and mesenteric lymph glands are enormously enlarged, and are hard and cheesy.

The mesentery is sprinkled with opaque, white areas. The brain is normal in appearance, with the exception of a white focus 1 mm. in diameter embedded in the pia mater lying over the subfrontal sulcus.

Record of monkey No. 2.—Small female Cebus, in unthrifty condition, hair rough and soiled in places, tested with tuberculin without reaction; weight 2 pounds 1 ounce. September 12, 1901, injected subcutaneously, left side, about 1 inch below udder, with $\frac{1}{4}$ c. c. of tubercle culture bovine III.

Condition as a result of the injection is similar to that described for monkey No. 1, in addition to which the mammary gland directly above the seat of injection is swollen and firm and the skin covering it, especially about the nipple, reddened. This animal gradually lost in condition, but remained fairly bright until the latter part of October. On October 12 its weight was 1 pound 14 ounces, on October 26 also 1 pound 14 ounces. On November 7 the following record was made: Weight 1 pound 12 $\frac{1}{2}$ ounces; condition very poor and unthrifty; hair roughened and much soiled; mammary gland greatly swollen and the skin over same, especially about the nipple, intensely reddened; ulcer at the seat of injection 1 inch long and $\frac{3}{4}$ inch broad; appetite very poor. On November 22 the monkey was in a dying condition and was chloroformed and examined postmortem.

Autopsy: The animal is very much emaciated. At the seat of injection is a large raw, ulcerated area, about 1 inch in diameter, over which the skin has entirely disappeared; the edges of the skin surrounding the opening are somewhat everted. Lung sprinkled with grayish, translucent foci from 1 to 20 mm. in diameter, the centers of which are opaque and of a yellowish white color. Liver apparently normal. Spleen of a dark color and studded with opaque yellowish white areas from 1 to 3 mm. in diameter. Kidneys pale and contain a number of translucent areas about $\frac{1}{2}$ mm. in diameter; the left kidney, on section, is found to contain a yellowish white, opaque, necrotic area about 3 mm. in diameter. Lymphatics—The axillary, mediastinal, and mesenteric glands are all enlarged and cheesy, and all, on section, show more or less softening and the presence of thick, white pus.

DESCRIPTION OF PLATE XXVI.

Sections of organs of monkey No. 3, indicating distribution of tubercle bacilli from subcutaneous inoculation with pure culture human tuberculosis No. 50. Stained with hematoxylin and carbol-fuchsin. Magnified 1,450 diameters.

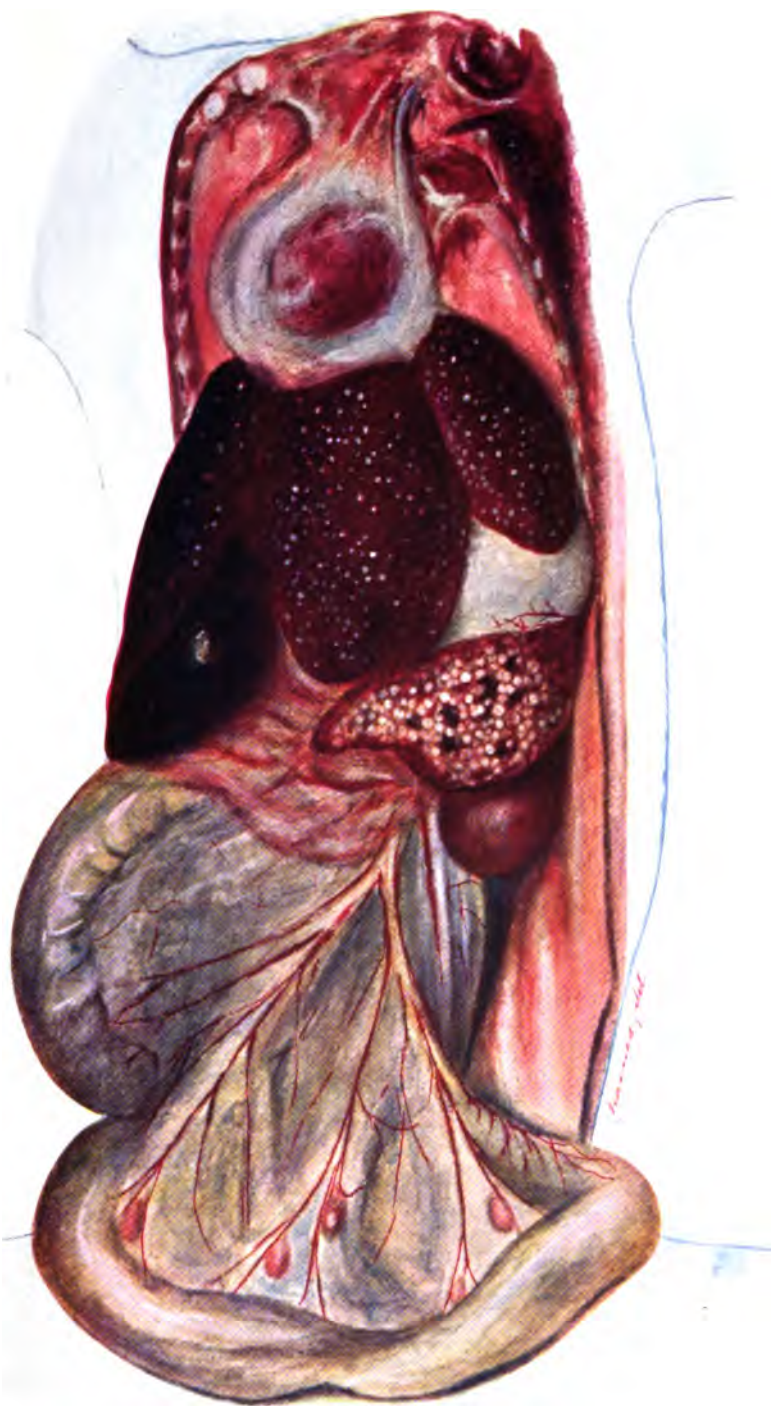
Fig. 1.—Section of lung.

Fig. 2.—Section of liver.

Drawing by W. S. D. Haines.



Lung, Sheep 41. Intravenous inoculation with pure culture human tuberculosis No. 50.





Monkey No. 7, Baboon. Fed on tuberculous milk. (Bovine tuberculosis.)

and those of bovine origin, but it is not a specific difference or even a difference which permits the grouping of the germs as distinct varieties of the same species, but a difference practically confined to pathogenic virulence, and which forces us to regard the tubercle bacilli of bovine origin merely as more virulent than those of human origin.

REVIEW OF SOME OF THE MORE RECENT EXPERIMENTS CONCERNING
THE INTERTRANSMISSIBILITY OF HUMAN AND BOVINE TUBERCULOSIS.

The well-known address of Prof. Robert Koch^a before the British Congress on Tuberculosis in July, 1901, caused an enormous awakening of interest among medical men in all that concerned the relationship of human to bovine tubercle bacilli. In the paper referred to Koch expressed the belief that the infection of man with tuberculosis from bovine sources is of such rare occurrence that no preventive measures are necessary in this direction. He was led to this belief by the lack of direct evidence that such infection had taken place, and by the experiments conducted by himself and Schütz,² in which it was found that a number of tubercle cultures from human sputum would not infect cattle or certain other domesticated animals. This London address led medical investigators the world over to make experiments and observations bearing more or less directly on the intertransmissibility of human and bovine tuberculosis. By the fall of 1902 a large amount of evidence had been presented to show that certain tubercle bacilli of human origin are capable of causing a generalized tuberculosis in cattle, and many instances of the infection of men from cattle had been reported. These reports, which possibly modified Professor Koch's views in regard to the pathogenic power of human tubercle bacilli for cattle, did not influence his opinion in regard to the danger to human beings from the use of tuberculous meat and milk, as is shown in his latest paper³ upon the subject. His views, as expressed in this paper, present the strongest possible statement of the position occupied by those who insist upon the noninfectiousness of bovine tuberculous virus for human beings. For that reason it seems desirable to quote in part the requirements which, in his opinion, should be met in order to establish the infectiousness of bovine tuberculosis for the human subject. The requirements are in part as follows:

1. Certain proof of tubercle in general and, where possible, the primary focus must be supplied. In adults we must, therefore, require the existence of unassailable clinical symptoms, and a necropsy when these are not present. In children the clinical symptoms are much too uncertain, and so a necropsy is always requisite with them.

2. Other sources of infection must be excluded with certainty. The assurance that the person in question comes of a healthy family is under no circumstances sufficient. There

^a These figures refer to bibliography on page 98.

are numerous other possibilities of infection either inside or outside the family which come up for consideration. * * *

3. In each case of alleged infection from milk infected with *perlsucht* bacilli the condition of the rest of the people who have taken the same milk should be borne in mind. These fellow-consumers form to a certain extent a control experiment, and if of the numerous people who have drunk the suspected milk only a single one sickens, this weighs decidedly against the belief that this one person was infected by the common food. * * *

4. The source of the milk should be attended to. Since in recent years it has become more and more evident that milk containing tubercle bacilli is yielded only by cows affected with tuberculosis of the udders, the general statement that someone has drunk milk from a cow suffering from *perlsucht* no longer suffices to prove to us that *perlsucht* bacilli have really reached that person's organs of digestion. A man can certainly ingest milk from a cow suffering from *perlsucht* without coming into contact with *perlsucht* bacilli through it. It must be milk from a cow with tuberculosis of the udder, and therefore a statement relative to this point should not be lacking in a report on milk infection if it is to be considered complete.

It will be seen from the above statement that Doctor Koch requires absolute and direct proof of the infection of men with bovine tuberculous virus before he will recede from his position that there is practically no danger to human beings from tuberculous meat and milk. We are inclined to regard some of the conditions imposed by him as unnecessary and unreasonable because, owing to the insidious onset of this disease, and the fact generally admitted that tubercle bacilli which have entered the body may lie dormant for years without producing any evidence of their presence, it is impossible to say with absolute certainty when or where any given case of human tuberculosis had its origin. We are, therefore, forced to rely almost wholly upon indirect evidence as to the infectiousness of bovine tuberculosis for men. In our opinion the intertransmissibility of human and bovine tuberculosis is supported by so much indirect evidence of an overwhelming character that we are justified in regarding it as practically established. Absolute proof is greatly to be desired, but in its absence we must be governed by probabilities and base our regulations for the control of tuberculosis on them.

In the following pages are reviewed some of the most recent experiments bearing upon human and bovine tuberculosis, together with a portion of the literature concerning the transmission of tuberculosis to animals by feeding.

EXPERIMENTS WHERE INFECTION WAS BY MEANS OF DIGESTIVE TRACT.

Dobroklonski⁴ has attempted to decide definitely the disputed questions whether tubercle bacilli can enter the body through the intestinal tract and whether a lesion of the intestinal mucous membrane is necessary for such infection to take place. The animals experimented upon were guinea pigs. The infecting material used consisted of tubercle cultures on glycerinized bouillon. A small glass tube with rounded ends was inserted into the throats of the guinea

pigs and a few drops of a pure culture were allowed to flow through it. The animals were not fed for some little time after they received the culture and were guarded carefully against any outside infection. They were killed on the fourth, tenth, fifteenth, twentieth, twenty-fifth, thirty-second, and fortieth days, respectively, after being fed the culture. At the autopsy a careful macroscopic examination was made of the entire length of the intestine, and microscopic sections were made from large portions of that organ, those portions which indicated the slightest variation from the normal being given specially careful study. As a result of this extremely laborious experiment the author found that it is entirely possible for tubercle bacilli to pass through the normal intestinal mucosa of guinea pigs. He is not able to say just how the entrance is effected, but draws the following conclusions:

Tuberculosis may certainly infect animals through the digestive tract. For this infection to take place, no lesion of the intestinal wall is necessary; no epithelial desquamation; no local changes of any character; no previous inflammatory process. The tuberculous virus—the bacilli as well as the spores (sic)—can easily pass through the epithelial covering of the perfectly normal intestine. This penetration is particularly easy in cases where the contact of the tuberculous virus with the intestinal wall is prolonged, but for the penetration to take place it is not necessary for this contact to be prolonged. The tubercle bacilli as well as their spores (sic), if they are not long in contact with the intestinal wall, are not capable of provoking inflammatory processes or modifications of the epithelial lining of this wall. The tubercle bacilli probably have no definite way of gaining entrance into the organism—for example, by leucocytes exclusively—but they may be carried by the lymph current and later being arrested at some places in the tissues they there give rise to the formation of tubercles.

Nocard⁵ says that in the case of cats, young animals are especially liable to contract tuberculosis through the digestive tract. He fed to four 6-weeks-old kittens and also to their mother a paste with which was mixed a very abundant culture of tubercle bacilli. All four kittens died within four months of a severe type of tuberculosis. The mother lived for a long time in good health, but when killed at the end of three years tuberculous lesions of the spleen, liver, and lung were found.

Clausen,⁶ while holding the position of slaughterhouse inspector in the town of Husum, in Germany, was struck by the fact that the hogs slaughtered for the almshouse and hospital were more or less infected with tuberculosis. Hogs of the same breed fed in other places, however, were entirely sound. The tuberculous changes were usually found in the liver, mesenteric glands, cervical glands,

or the lungs. Hogs suffering from generalized tuberculosis had to be condemned as unfit for human food. On this account it became very desirable to find the cause of this disease. As the hogs at the almshouse were supposed to be fed only upon barley, corn meal, cooked potatoes, and some green fodder, the food was not at first suspected. The stalls were in very good condition; nevertheless, before the introduction of fresh hogs they were cleansed with hot soda solution and disinfected with carbolic acid, and fresh lime was scattered over them. One day, quite accidentally, Clausen noticed that the refuse from the hospital portion of the institution, in which a number of tuberculous patients were being cared for, was thrown out to the hogs. He forbade the further continuance of this practice, and never found another tuberculous hog at that institution. As a result of this observation the author is convinced that hogs may contract tuberculosis directly from men. He consulted his day-book and found that hogs which had been cared for by men suffering with tuberculosis often showed that disease when slaughtered.

Tjaden⁷ reviews the statistics concerning primary intestinal tuberculosis in children and also reports some experiments conducted by himself in collaboration with Hertel and Koske. They fed milk from tuberculous cows to sixteen young pigs. Only one of these developed a primary intestinal tuberculosis. The others had an infection of the mesenteric and also of the cervical lymph glands. From this fact the author infers that a great number of the cases of tuberculosis of the cervical glands in children may be caused by tuberculous milk, and that infection through the food is not always indicated by tuberculosis of the intestines.

Nocard⁸ used six monkeys of the same origin for an experiment, which was briefly as follows: Three of the monkeys were reserved as checks. They remained perfectly healthy. The other three, which were fed several rations containing a small amount of a culture of bovine tubercle bacilli, became tuberculous after a short time. The localization of the lesions thus produced showed clearly that the intestinal mucous membrane was the entrance point of the virus, and there can be no doubt that the infection was the result of eating the infected food. The monkeys showed the same susceptibility to bovine tuberculosis that is seen in all other mammals; therefore, in Nocard's opinion, we have no right to suppose that there is a difference in the case of children. The milk from a cow suffering with udder tuberculosis must be considered as especially dangerous.

Cipollina⁹ records the results obtained by feeding an ape with cow's milk, to which had been added a pure culture of bovine tubercle bacilli in the proportion of 1 öse to 150 c. c. of milk. This feeding was kept up for a month, the tubercle bacilli being administered every other day. Before the feeding commenced the animal was

crawling, which facilitates the breathing of dust charged with tubercle bacilli.

Heller shows the infectiousness of bovine tuberculosis for man in a very striking and well-investigated case, in which a man who pricked milk into his skin in order to remove tattoo marks developed lupus at the point of inoculation. On the ground of these investigations Heller strongly opposes a relaxation of the former regulations for the control of bovine tuberculosis.

INOCULATION EXPERIMENTS.

Cipollina⁹ describes the inoculation of a calf with a culture of human tuberculosis; details not given. The inoculation was made in the following manner: The animal was allowed to inhale tubercle bacilli through an opening in the trachea, and also received an intraperitoneal injection of 10 c. c. of the same culture. After twenty days the animal was well and was inoculated for the second time intraperitoneally with 20 c. c. of the same culture. The animal died after two months, but showed no signs of tuberculosis. The author concludes that cattle are very resistant to human bacilli, but in the light of researches upon ordinary experimental animals he believes that the human bacillus may infect all animals that are susceptible to the bovine bacillus, the only difference being that the latter is almost always more virulent than the former. This explains why cattle can resist human tuberculosis and succumb to bovine tuberculosis, and what is true of other animals is probably also true of man. The bacillus of bovine tuberculosis is, therefore, more virulent for man than the human bacillus itself.

Bang¹⁴ noted the following in regard to his experiments upon the transmission of human tuberculosis to cattle. In two instances human tuberculosis was inoculated into the anterior chamber of the eye of calves with positive results. In the first case the material was taken from a tuberculous human lung. A guinea pig was inoculated with this material and the spleen of this guinea pig furnished material for the inoculation in both eyes of an 8-weeks-old calf. The primary inflammation was unimportant and quickly disappeared, but about eighteen days later a severe tuberculous iritis and conjunctivitis developed. After about seven weeks the calf was killed. At the autopsy both eyes showed a distinct tuberculous iritis. The other organs of the body, however, exhibited no changes. In the second case Bang injected into the anterior chamber of the eye of an 8-weeks-old calf some pus which was obtained from the tuberculous lymph gland of a child. The result was quite similar to that in the first case. The pus was quickly absorbed and a week after the inoculation the eye was apparently in a normal condition. Three weeks after the inoculation a tuberculous iritis developed and was followed

by a keratitis and a conjunctivitis. Four and one-half months after the inoculation the iris was studded with white nodules.

Both of these cases show that human tuberculosis is communicable to cattle. They indicate also, however, that human tuberculosis pursues a slower and more benign course in cattle than the true bovine tuberculosis.

Orth¹⁵ reports the following experiments: Three calves, three hogs, and three goats were used. The animals were all obtained from yards which were known to be free from infection, and the calves gave a negative reaction to the tuberculin test shortly before the commencement of the experiments. The infectious material was obtained from a case of phthisis cavernosa by inoculating a guinea pig and then obtaining cultures from this animal upon brain and other media. In the experiments bouillon cultures of the organisms were used and in some cases tuberculous organs from rabbits which had been injected with such cultures.

Of the three calves, the first one, which received a bouillon culture, injected into the lung through the trachea, gave an entirely negative result. The second, which was inoculated between the abdominal muscles with a suspension of the pure culture, showed only a local caseous abscess. Both animals were killed five and one-half months after the beginning of the experiment. The third calf, which was inoculated in the peritoneal cavity with two pieces of tuberculous kidney from a rabbit, died on the twenty-sixth day of a general tuberculous peritonitis. The serous membranes were covered with miliary and submiliary tubercles. The great omentum, which was adherent to the peritoneum, was sprinkled throughout with nodules. Small nodules were visible on the serous membrane of the intestines. The mesenteric, portal, and cardiac lymph glands were much enlarged and showed grayish-white nodules upon section. The retrosternal lymph glands were much enlarged and congested, and small nodules were visible upon section. The left shoulder gland and other lymph glands were swollen and some exhibited tuberculous changes. The other organs were free from tuberculosis. The microscopic examination of the peritoneal nodules and the various lymph glands, especially the retrosternal and submaxillary glands, showed typical tuberculous granulations containing giant cells and many tubercle bacilli, which were especially abundant in the giant cells.

The guinea pig inoculated from this calf died within a few days, so that this experiment could not be carried further. It can be said, however, that human tuberculosis has been communicated to a calf, and not simply a local disease, but a progressive, fatal tuberculosis was produced. There can be no doubt that this calf was infected with human tuberculosis, for in the author's various experimental animals no case of spontaneous tuberculosis had developed and no bovine

inoculations had been made. The condition of the calf could not be ascribed to the action of dead bacilli, for the bacilli with which the calf was inoculated were inclosed in a tuberculous kidney tissue and must have spread over the entire peritoneum and also to portions of the body far removed from the point of inoculation.

In the case of the three hogs, the two which were inoculated intraperitoneally with the bouillon culture gave practically negative results. The third hog was inoculated through the trachea into the lungs with a bouillon culture. After five and one-half months the animal was killed. In the thymus gland and in the membranes around it there were many yellowish tuberculous nodules. The left lung was free from tuberculosis, but in the inferior lobe of the right lung there were found a large number of submiliary and miliary tubercles. No other tuberculous changes were found. The microscopic examination of the nodules presented a typical picture of tuberculous granulations containing giant cells and exhibiting a central caseation. Tubercle bacilli were present.

The three goats all showed tuberculosis following inoculation, though it is worthy of note that the two most marked cases resulted from inoculation with the tuberculous organs of a rabbit. The first animal, which was inoculated with a bouillon culture through the trachea into the lung, showed a number of subcutaneous nodules near the point of inoculation, a large caseous nodule in the thymus gland and a number of yellowish gray nodules in the inferior lobes of the right and left lungs. No lesions were found in the abdominal viscera except a few yellowish nodules in the liver, which, upon microscopic examination, were found to be tuberculous in character.

The second goat was inoculated intraperitoneally with a small piece of lung from a tuberculous rabbit. The animal was killed after five months and showed the following lesions: A number of nodules in the muscles and subcutaneous tissue at the point of inoculation. A number of small grayish, translucent nodules were found scattered through the omentum. They were found especially in the portion near the stomach and some of them hung by small pedicles resembling polypi. Similar changes were found in smaller number on the diaphragm and in the neighborhood of the lymph glands surrounding the heart. On the pleural surface of the diaphragm these nodules occurred singly. On the anterior border of the liver near the gall bladder there was found a nodule about the size of a pea. Microscopic examination showed the nodules to be tuberculous granulations containing giant cells with a necrotic center and often lime salts were present. Bacilli were found, although in small numbers.

The greatest changes were found in the third goat, which was inoculated with the same tuberculous kidney with which calf No. 3 was inoculated. A fragment about the size of a bean was intro-

duced into the peritoneal cavity of the goat. The animal was killed at the end of five and one-half months. A number of tubercles were found around the point of inoculation. There was a large group of caseous nodules on the adjoining surface of the stomach, numerous caseous nodules in the omentum, many of these latter having small pedicles. There were some nodules and granulation tissue attached to the capsule of the liver. The interior of this organ, however, was free from tuberculosis. The retroperitoneal lymph glands were very large but not caseous. All other organs appeared to be normal. Nodules from the various diseased areas were examined microscopically and showed tuberculous new formations with giant cells, central necrosis, and calcification. Tubercle bacilli were easily demonstrated. There can be no doubt as to the tuberculous character of the lesions described nor that they were produced by human tubercle bacilli. Therefore the author takes issue with Koch's statement that tuberculosis of man can not be communicated to cattle.

To answer the question as to whether he has really obtained a perlsucht or simply a tuberculosis different from that of cattle, the author points out that in the third goat the abdominal lesions were entirely of the perlsucht character. He also points to the case reported by Baumgarten in which by injection of perlsucht bacilli into cattle, a generalized miliary tuberculosis was produced without any resemblance to the typical perlsucht. The morphological changes can not be relied upon to differentiate between human and bovine tuberculosis, because these changes depend upon the condition of the animal as well as upon the organism itself. How little the perlsucht form of a tuberculous disease is dependent upon the perlsucht bacillus has been shown by Troje and Tangl who, by subjecting human tubercle bacilli to the vapor of iodoform, succeeded in producing a typical perlsucht in rabbits.

Orth concludes that it is proven that human tuberculosis can be communicated to cattle. It must be remembered also that the danger of the communication of bovine tuberculosis depends not only upon the transmission of bovine bacilli, but also upon the constitution of the person who is exposed to them.

Fibiger and Jensen¹⁶ report the results of their experiments with human tuberculous material obtained from the various hospitals of Copenhagen. They report in all five cases of tuberculosis in the following subjects: (1) 42-year-old woman, (2) 11-year-old girl, (3) 6-year-old boy, (4) 19-months-old girl, and (5) 4-months-old boy. In all of these cases the infection appears to have begun in the intestines and in some the disease was practically confined to the abdominal organs.

(1) A 3-months-old calf was inoculated in the thoracic cavity with a suspension made from a mesenteric gland of case No. 1. This calf

remained apparently in good condition and was killed at the end of six months. Two miliary tubercles were found on the pleura and a few fresh pearl nodules were found on the pulmonary pleura; otherwise the animal was in good health.

(2) A 3-months-old calf which had been subjected to the tuberculin test was inoculated intraperitoneally with a suspension made from the spleen of a guinea pig which had been inoculated with a mesenteric gland from case No. 2. The health of the calf was not visibly affected by the inoculation. It was killed at the end of the fifth month. In the omentum was found a large number of small red growths and about twenty small, fresh, pearl nodules. On the diaphragm, also, there were some small nodules and excrescences; on the pulmonary pleura a few excrescences.

(3) A calf 2 to 3 months old which had withstood the tuberculin test was inoculated intraperitoneally with a suspension made from the spleen of a guinea pig which had been inoculated from case No. 3. There were no acute symptoms following the inoculation, although at the end of three weeks and later there was a slight rise in temperature. The calf was killed about the end of the fifth month. The omentum was filled with tuberculous new growths and showed countless small nodules of varying size. All lesions were recent; a few showed traces of caseation. There were some small nodules found on other portions of the peritoneum. The surface of the spleen and liver was covered with small pearl nodules, as was the diaphragm. Some of the mesenteric glands were enlarged. In the lungs a few small areas of atelectasis; no tuberculosis. The bronchial and posterior mediastinal glands were enlarged but showed no caseation.

(4) A calf 2 to 3 months old which had been subjected to the tuberculin test was inoculated subcutaneously on the right side of the neck with a suspension made from the mesenteric gland of case No. 3. The animal showed no very marked symptoms following the inoculation and was killed at the end of the seventh month. There was a large caseous mass at point of inoculation. The neighboring glands were enlarged, caseous, and calcified. The lungs had scattered through them many small miliary nodules and there were a number of excrescences attached to the pulmonary pleura. No caseation in these excrescences. The bronchial and posterior mediastinal glands were enlarged, hard, and dotted with fresh caseous and calcified nodules. The liver and spleen had scattered through them miliary tubercles. The omentum was filled with fine, diffused, red, new growths. In the mesenteric glands there was no evidence of tuberculosis.

(5) Two 10-days-old calves were inoculated subcutaneously on the side of the neck with a suspension made from a mesenteric gland

from case No. 5. Both of these animals died within three weeks of the inoculation and evidently from secondary infection. Although the calves died so soon there developed, nevertheless, a considerable local tuberculosis rich in bacilli

From calf No. 2, case 5, a third calf was inoculated and from calf No. 1 an old cow was inoculated. Calf No. 3, inoculated from calf No. 2, was fourteen days old and was injected subcutaneously in the right side of the neck. A large abscess formed at the point of injection. At the end of about two months the calf, being in a dying condition, was killed. The autopsy showed, in addition to the local lesions, tuberculosis of the adjacent lymph glands. There were many new growths on the costal and pulmonary pleura and also on the pulmonary surface of the diaphragm. The lungs contained a countless number of minute nodules, some of which were as large as hemp seed. The bronchial and mediastinal glands were enlarged and caseous. The liver, spleen, and kidneys had miliary tubercles scattered through them. The intestinal wall was very rich in fresh nodules and small superficial ulcerations. The mesenteric glands were enlarged and tuberculous. The omentum was rich in small new growths.

A cow about 10 years old, inoculated on the left side of the neck with material from calf No. 1, developed a phlegmonous abscess at the point of inoculation which was accompanied by fever, and tubercle bacilli were found in the pus. At the end of four months the cow was killed. In addition to the local abscess the neighboring glands were enlarged, caseous, and calcified. Miliary tubercles were scattered through the lungs. In the posterior mediastinal gland a nodule was found the size of a pea; in the liver, a small number of miliary tubercles. The other organs were normal.

Thus, in three cases of tuberculosis in children the bacilli present were virulent, some of them in the highest degree, for calves, and it is probable that the disease in the children was caused by bacilli which came from cattle. In the five cases the greatest variation in virulence for calves was found, ranging from nothing to the highest degree, and it is especially noteworthy that the virulence of these bacilli seemed to decrease as the age of the patient increased. Koch claimed that one could distinguish between human and bovine tuberculosis by inoculating calves subcutaneously. If this is true, then three of the cases above cited must be considered as *perlsucht*, and the assertion that tuberculosis of cattle is not virulent for men is disproved.

Karliński¹⁷ succeeded in communicating tuberculosis to cattle by means of human tuberculous virus ten times in twenty-three attempts. The mode of inoculation varied. Some of the animals were inoculated intraperitoneally, some intrapleurally, some intra-

tracheally, some into the udder, and some subcutaneously. He compared the cultures of human and bovine tubercle bacilli, but found absolutely no difference between them, either microscopically or macroscopically, except in the rapidity of growth. He considers that the chief difference is the greater resistance of cattle to human than to bovine bacilli. He has attempted to increase the virulence of the human tubercle bacillus by passing it through calves. With this object in view he inoculated one calf subcutaneously and intraperitoneally at the same time. At the end of two months the animal showed a distinct tuberculin reaction and was killed, and tuberculous changes were found in the mesenteric glands, liver, and spleen; some of the lesions showed a caseous degeneration. He recovered a culture from this animal and inoculated a second calf. This calf showed a tuberculin reaction in less than a month, but was allowed to live until the end of two months, when it was killed and showed a much more generalized tuberculosis than was found in the first animal, thus indicating that this particular tubercle culture had been increased in virulence by its passage through a calf.

Thomassen,¹⁸ in the spring of 1899, tested two calves, aged 8 and 4 weeks, with tuberculin, obtaining negative results. The milk with which these animals were fed was taken from a cow which did not react to tuberculin. The 8-weeks-old calf received intraabdominally a culture upon glycerinized potato which was derived from the cerebral exudate of a child affected with tubercular meningitis. The animal remained well and was tested with tuberculin after two months and gave a good reaction. When the animal was killed, however, one month later, notwithstanding a most careful post-mortem examination, no trace of tuberculosis was found. The calf 4 weeks old was inoculated in the anterior chamber of the eye with a culture of tuberculosis upon glycerinized potato which was derived from a case of tuberculous arthritis. After about a month this animal was tested with tuberculin, but failed to react. It was killed a short time afterwards and found to be affected with a generalized tuberculosis. The progress of the infection from the eye to the lungs was easily traced through the chain of lymphatic glands.

Some months later a cow about 2 years old, in perfect health, was tested with tuberculin and did not react. Shortly afterwards this animal was injected in the trachea with a culture of tuberculosis grown upon potato. This culture was obtained from a case of human renal tuberculosis. After two months a tuberculin injection failed to produce reaction. A few days after this second tuberculin test a culture was injected into the thorax and into the abdominal cavity. In making the abdominal injection some of the material was deposited in the muscular tissue. As a result of this an abscess containing purulent material formed and was found to contain

tubercle bacilli. After five months the animal was tested with tuberculin without reaction. About ten months after this the animal was killed and showed not the slightest trace of tuberculosis. A fourth cow, 2 years old, was tested with tuberculin without reaction, and a culture of tuberculosis obtained from a case of renal disease in a man was injected into the anterior chamber of the eye. This animal after two months gave a marked tuberculin reaction, and was in very bad health. Six months after the inoculation the animal was killed. There were tuberculous lesions in the eye and in one bronchial gland, but unfortunately a histological examination could not be made. Thomassen's experiments show that it is difficult, but not impossible, to produce tuberculosis in cattle by means of cultures of the human bacillus. He thinks the much greater virulence of the bovine bacillus, which is generally admitted, should urge, contrary to the advice of Koch, a most rigid inspection of all meat and milk.

Arloing¹⁹ inoculated thirty-three animals of various species with bacilli of human origin. The results were positive in every instance. Five separate cultures of human tuberculosis were used, cattle, sheep, goats, donkeys, and hogs were infected by intravenous injections and exhibited tuberculous lesions of different degrees. The human cultures varied greatly in virulence, but microscopic examination demonstrated that even the weakest had produced true tuberculous lesions. Compared with injections of bovine virus it can be said that, as a rule, the bovine virus is more virulent than the human, as all of the animals inoculated with bovine tuberculosis died within forty-four days, at the most, and the majority of those inoculated with human bacilli were killed. Arloing concludes:

(1) Human tuberculosis is infectious for cattle, and at times, by certain methods of inoculation, it brings about lesions having the character of bovine tuberculosis.

(2) The human bacillus is not always of the same virulence and does not show the same degree of activity toward different species of herbivora.

(3) In some cases human bacilli are as virulent as germs of bovine origin. In other instances, on the contrary, the virulence is so reduced that it appears to be nil, especially for the bovine species.

(4) Human bacilli of attenuated virulence always produce in the lung at least, following intravenous injections, lesions which are visible with the microscope.

(5) The variations in the virulence of the bacillus account for the apparent negative results which have led Messrs. Koch and Schütz to believe in the duality of species. The unity of human and bovine tuberculosis should be maintained, and prophylactic measures which arise therefrom should be continued, especially with regard to the use of milk.

Ravenel²⁰ describes two cultures of the tubercle bacillus obtained from the mesenteric glands of two children. One (culture B B) he found to be quite as virulent for calves upon intravenous inoculation as the bovine bacillus, and the other (culture U) had a virulence decidedly above that of the ordinary human cultures. Culture

B B corresponded morphologically and culturally more nearly to the bovine type than to the human. He also reports the results of another experiment made by Dr. Leonard Pearson, in which a calf received large amounts (925 c. c. in all) of a human tubercle culture of moderate virulence at intervals extending over a period of four months, in the form of subcutaneous, intravenous, intrapulmonary, and intraperitoneal injections. This culture after successive passages through calves, showed a great increase in virulence.

Stenström²¹ records experiments upon calves of reaction-free cows which were raised on boiled milk. Eight of these calves were inoculated in various ways with tuberculous sputum which was rich in tubercle bacilli. Three of the calves died shortly after inoculation and were left out of count. The remaining five were slaughtered six months after inoculation, and the autopsies showed the following results: Calf No. 820, inoculated into the lung, showed many* tuberculous adhesions upon the costal and diaphragmatic pleura, as well as tuberculous areas in the mediastinal glands. Calf No. 833, infected by intratracheal injections, showed partly calcified areas in the anterior and posterior mediastinal glands and in the bronchial glands. Calf No. 224, inoculated intraperitoneally, showed many calcified areas in the omentum and enlargements of the glands within it, a fibrous exudate on the serous membrane of the peritoneal cavity, many tuberculous areas in the liver the size of a pinhead, and some adhesions on the surface of the right lung. Calf No. 94 had pulverized sputum sprayed into the nose and showed only slight inflammation of the pulmonary pleura. Calf No. 818, inoculated subcutaneously, showed only a large abscess at the point of injection and a proliferation of tissue around this abscess.

These results differ from those of Koch. None of Koch's nineteen calves showed any tuberculosis of the internal organs after six or eight months; only a small pus area containing a few tubercle bacilli was found. Stenström found in his animals that the tuberculosis spread from the point of infection to the internal organs and lymph glands, and also to the serous membranes. Indeed, in No. 224 tuberculous areas were found in the liver. Koch's assertion that human tuberculosis is different from bovine tuberculosis, and that human tuberculosis can not be communicated to cattle is opposed by this investigator, who found it quite easy to infect cattle with human tuberculosis, although he recognizes that human tubercle bacilli are relatively less virulent for cattle than bovine bacilli. He believes if his animals had been allowed to live longer, and had been subjected to unfavorable conditions such as illness, and so forth, the disease would possibly have been more advanced. In other words, a generalized tuberculosis is not necessary to prove that infection has taken place, as it is well known that bovine tubercu-

losis can remain local for many years, and at the autopsy only a few small tuberculous areas in the lymph glands are found.

Nocard²² has been able by the use of collodion sacs containing human or bovine tubercle cultures introduced into the peritoneal cavity of fowls to transform these mammalian tubercle bacilli into cultures which have the morphological and cultural characteristics of avian tubercle bacilli and which possess a virulence for fowls equal to that of the avian tubercle bacillus, but their virulence for guinea pigs was apparently lost.

Svensson²³ attempted to infect healthy calves with tuberculous sputum by means of subcutaneous intratracheal, intraperitoneal, and intrapulmonary injections or through the inhalation of pulverized sputum. About six months after the beginning of the experiment the animals were killed, and the autopsies showed that the serous membranes, as well as the lymph glands in the neighborhood of the inoculations, were tuberculous. In the opinion of the author his experiments show that the human tubercle bacillus possesses relatively slight virulence for cattle.

Dean and Todd²⁴ made some experiments, the object of which was to ascertain whether the human tubercle bacillus undergoes any marked change in virulence for cattle by passage through the pig, cat, rat, rabbit, or mouse. The authors give an account of their experiments in detail and reach the following general conclusions:

(1) That the hog is capable of contracting a rapidly fatal generalized tuberculosis as the result of infection with the human bacillus.

(2) That the human tubercle bacillus is not markedly increased in virulence for the calf by a single passage through the pig, cat, rat, or rabbit.

(3) That the human tubercle bacillus is by no means innocuous to the calf, as the control animal injected directly with sputum contracted an extensive glandular tuberculosis.

The authors used tuberculous sputum for all of their inoculations instead of pure culture. They noted that sometimes the first animals in a series died earlier than those inoculated later with tissue from the first animal. They explain this by calling attention to the fact that in the case of the second inoculation the tubercle bacillus was present almost always alone, whereas in the sputum inoculations at the beginning of the series many other bacteria were associated with the tubercle bacillus, and the earlier death of the first animals in some cases is to be attributed to the action of the associated organisms rather than to a more exalted virulence of the tubercle bacillus.

De Jong²⁵ describes, in the latter part of his paper, experiments which he made with a bacillus of human origin, which is very virulent

for cattle. The material was obtained from a peasant woman 27 years of age, without hereditary taint, whose occupation brought her in frequent contact with animals. This woman was affected with pulmonary tuberculosis and a guinea pig inoculated with some of her sputum became tuberculous. Cultures from the spleen of this guinea pig served for the two following experiments:

A calf 6 weeks old, weighing 65 kilograms, received in the jugular vein 6 c. c. of an emulsion of culture. The animal had not reacted to tuberculin. Five days after the injection the temperature exceeded 40° C., and it remained elevated until death, which took place at the end of nineteen days. The weight had fallen to 53 kilograms. The autopsy showed extensive tuberculous lesions of the lungs, liver, spleen, kidneys, and lymphatic glands. On the pleura were found alterations characteristic of the early stages of pearl disease.

A goat which was likewise perfectly healthy, weighing 17 kilograms, was inoculated in the jugular vein with 5 c. c. of the same emulsion. This animal died in twelve days of a generalized tuberculosis.

Two other inoculation experiments with this same bacillus are also reported. One was an intrapulmonary injection of a calf and was followed by a generalized tuberculosis. The other was a subcutaneous inoculation of a calf with the same culture, death taking place at the end of fifty-six days. The weight had fallen from 58 kilograms at the beginning of the experiment to 53 kilograms at the time of death. The autopsy revealed very severe generalized tuberculosis, involving the lungs, liver, spleen, kidneys, and lymphatic glands.

It can not be denied that the above case of human tuberculosis is an instance of infection by the bovine bacillus, or by a human bacillus which possessed equal virulence with the bovine bacillus for cattle. Either one of these hypotheses contradicts the theory put forth by Koch.

Wolff²⁶ mentions a case of primary human intestinal tuberculosis, the virus from which produced generalized tuberculosis in a calf. This case was previously reported in the *Deutsche Med. Wochenschrift*, 1902, No. 32, where all the details are given of the care which was taken in the inoculation of the virus into a tuberculosis-free calf (tested with tuberculin); also of the clinical course of the disease which followed the subcutaneous injection into the neck, the fact that the animal twice gave an exquisite tuberculin reaction at four and eleven weeks after injection, and, finally, the autopsy upon the calf and the microscopic examination eighty-three days after the beginning of the experiment. The autopsy showed the greatest alterations at the point of inoculation, and in the inner organs

changes that are typical of perlsucht. Briefly, the autopsy record is as follows: At the point of inoculation in the neck were found the oldest lesions. A tumor about the size of a child's head with a central cavity which contained a caseous pus, the cavity surrounded by a thick granulation membrane and sprinkled with calcareous deposits. In the neighborhood of the cavity were several glands the size of a small apple, with numerous caseous and calcareous nodules. In the neighborhood of the point of injection the shoulder glands and the pharyngeal glands were greatly swollen with caseous and calcified nodules. The pleura, pericardium, omentum, and the capsules of the spleen and liver were covered with characteristic tumors which varied in size from a millet seed to lentil, bean, and cherry sized nodules. In addition, tumors were found on the serous membranes and in the lung tissue. In the pulp of the spleen, and in the parenchyma of the liver and kidneys, miliary nodules were visible. The microscopic examination of these nodules frequently showed typical epithelioid-celled tubercles, together with giant and round cells, their structure being very similar to the human tubercle. Tubercle bacilli were found in the nodules of all the organs. Upon section and examination of the microscopic preparations, caseation and calcification of the tuberculous new growths at the point of injection and the neighboring glands were found, while the nodules in all distant organs (pleura, pericardium, lung, omentum, liver, spleen, and kidneys) were still fresh and showed neither caseation nor calcification. This microscopic evidence in connection with the identical macroscopic appearance, namely, the fact that the calcification and caseation were found only at the point of injection and in the neighboring glands, and, further, the clinical symptoms which were observed, indicate with certainty that the tuberculous process began first of all at the point of injection and spread from there, producing a general infection of the organism. Taking everything into consideration, there can be no doubt that here is a case of virulent perlsucht in a calf, which was brought about by the inoculation of material from a case of primary intestinal tuberculosis in man. According to Koch, such an inoculation of a calf with tuberculous material from such a case of primary intestinal tuberculosis will enable us to determine positively whether the infection was of human or bovine origin.

The author concludes his paper with a general discussion of the tuberculosis question, and takes the position that even if all the experimental proof of the identity of human and bovine tuberculosis is faulty, we should still, so long as there is any doubt about the transmissibility of bovine tuberculosis to man, take precautions to prevent possible infection.

Theobald Smith²⁷, in a recent communication to the Association of

American Physicians, described a culture of tuberculosis, isolated from the mesenteric gland of a child, which corresponded morphologically and culturally quite closely to the bovine bacilli with which it was compared. A steer inoculated intrathoracically with this culture became quite ill and was killed thirty-eight days after the inoculation. The autopsy and subsequent microscopic examination revealed tuberculosis of the lungs, mediastinal lymph glands, the liver, and the spleen. The pathogenic power of the culture appeared to be slightly below that of the ordinary bovine tubercle bacillus, but it undoubtedly possessed the ability to produce a genuine tuberculosis in the inoculated steer. Doctor Smith is of the opinion that this organism, on account of its cultural characters, its morphology, and its pathogenic power, should be considered as a bovine bacillus, and that the child from whom the culture was obtained was probably infected directly from cattle through milk.

Park²⁸ fed tuberculous sputum to four nonreacting calves and at the same time inoculated them subcutaneously with similar sputum. A fifth calf served as a control. After two and one-half months three of the calves reacted to tuberculin. At the autopsy one of them showed a few enlarged lymph glands, but without tubercles. The others had gained in weight. The tuberculin reaction in these cases Park attributes to the abscess at the seat of inoculation.

Mursajew²⁹ conducted a number of experiments to determine the relation between human and avian tuberculosis. He isolated a number of avian cultures and inoculated guinea pigs, rabbits, and pigeons with both varieties. He found that pigeons are generally fairly resistant to avian tuberculosis and says that their susceptibility to human tuberculosis is not very great, although their susceptibility to both organisms is influenced considerably by starvation. A passage of human tubercle bacilli through the pigeon's body does not increase their virulence for pigeons. Guinea pigs are quite susceptible to both forms of tuberculosis. There are certain slight differences in the pathological changes produced by the two strains of tubercle bacilli, but they are slight and amount to very little. Of five rabbits the author succeeded in infecting two with avian tuberculosis. He does not believe that the virulence of tubercle bacilli is increased by their passage through the bodies of animals.

Karlinski³⁰ reports fourteen attempts to communicate tuberculosis to cattle. The human cultures were all derived from sputum. Cattle were inoculated by different methods, some intravenously, some intraperitoneally, some subcutaneously. Certain cattle were inoculated with the human bacillus cultivated directly upon Hesse's medium without passage through the animal body. Others were inoculated with the same cultures which had been passed through several guinea pigs. In certain instances the human virus was transferred

from one calf to another in order to determine the effect of such passages upon the virulence of the human bacillus. Certain of the animal cultures were grown upon beef serum which was derived from an animal which had been previously inoculated with human tuberculosis. The author considers that thirteen out of fourteen experiments were successful in communicating human tuberculosis to cattle; also that the virulence of the tubercle bacilli was sensibly increased by passage through guinea pigs, and that human tubercle bacilli which have passed through cattle are markedly increased in virulence for cattle. As a result of these experiments Karlinski states that it is possible to communicate human tuberculosis to the usually resistant Bosnian cattle; that the disease affects primarily the lymph system, but a generalized tuberculosis may be produced by certain means, such as increase of virulence by passage through guinea pigs or cattle, and by intravenous inoculations. In his opinion no distinction should be made between human and bovine tuberculosis.

Fibiger and Jensen³¹ quite recently reported experiments with 5 additional human tuberculosis cultures. These cultures were obtained from: (1) A man 92 years old, who died of primary intestinal tuberculosis; (2) a girl 12 years old, who died of a generalized tuberculosis which apparently originated in the intestine; (3) a girl 7 years old, who died of a tuberculosis which had its origin in the intestine; (4) a man 40 years old, who died of an intestinal tuberculosis; (5) a child 3½ years old, who died of a generalized miliary tuberculosis.

Material taken from case No. 1 was apparently completely lacking in virulence for a calf when inoculated subcutaneously. A calf inoculated subcutaneously with material taken from a mesenteric gland of case No. 2 developed a tuberculosis of the shoulder gland and of the inferior glands of the neck. This culture evidently possessed little virulence for cattle. The spleen of a guinea pig which had been inoculated with a portion of a mesenteric gland of case No. 3 caused a generalized tuberculosis in a calf on subcutaneous inoculation. Material from a mesenteric gland from case No. 4 produced generalized miliary tuberculosis in a calf on subcutaneous inoculation. A portion of the liver of a guinea pig which contracted tuberculosis as the result of inoculation with material from case No. 5 was used for the subcutaneous inoculation of a calf in which it produced a localized tuberculosis associated with enlargement, caseation, and calcification of the shoulder and of the neck glands on the side of inoculation.

Among the ten cases quoted by Fibiger and Jensen in their two papers, we find that of the four adults from whom material was obtained one furnished a virus which was capable of causing a generalized tuberculosis in cattle. The other three were either entirely lacking in virulence or of only very weak virulence for cattle. Of the six children, four furnished tubercle bacilli of great virulence and two

furnished bacilli of low virulence for cattle. Eight of the cases of human tuberculosis were apparently due to a primary intestinal infection. Out of five cases of primary intestinal tuberculosis in children, four furnished bacilli which were of marked virulence for cattle.

The German Commission, headed by Kossel³², which was appointed to inquire into the various questions raised by Koch in his London paper, reported the isolation of thirty-nine cultures from various cases of human tuberculosis. Nineteen of these cultures produced no lesions in cattle after subcutaneous inoculation; nine cultures produced very slight tuberculous changes in the prescapular gland adjacent to the point of inoculation; seven cultures caused a more marked affection of the prescapular glands, but the disease did not spread to other portions of the lymphatic system; and the remaining four cultures of human origin caused a generalized tuberculosis in the calves which were inoculated subcutaneously with them. It will be seen, therefore, that four of the human tuberculosis cultures, or slightly more than 10 per cent, produced generalized tuberculosis in cattle, and it is very significant that these four most virulent cultures were all obtained from children, who, it is generally admitted, are in more danger of exposure to bovine tuberculosis through food than adults who consume proportionately very much less milk.

COMBINED FEEDING AND INOCULATION EXPERIMENTS.

De Haan³³, after a few subcutaneous and intravenous inoculations of goats, cattle, monkeys, and a horse, and after some feeding experiments with monkeys, a pure culture of human tuberculosis from sputum being used in all cases, formulates the following conclusions:

(1) It is possible to bring about in Javanese goats, cattle, and horses, by inoculation with human tubercle bacilli from sputum, certain pathological changes in the tissues which, macroscopically as well as microscopically, agree perfectly with the lesions found in Europe in animals which have been infected in a natural manner. The animals which showed these changes were not in the best of health at the time of inoculation. Perfectly healthy sheep and cattle were able to resist infection with the tuberculous material.

(2) There does not exist in the above-named animals a race immunity from tuberculosis. The absence of this disease among the animals of Java must be ascribed to other causes.

(3) The monkey is quite susceptible to infection with tubercle bacilli of human origin.

(4) The feeding of material containing tubercle bacilli can give rise to a tuberculosis of the lungs and of the bronchial lymph glands, together with—

(a) A tuberculosis of the mesenteric lymph glands without perceptible change in the intestines;

(b) Without any other localization of the tuberculous process.

(5) The lungs are the point of predilection for the development of tuberculosis.

Delépine³⁴ used a mixture of various tuberculous sputa, because tubercle cultures are apt to lose in great part their virulence and also because tuberculous material from man varies greatly in virulence. Six different specimens of sputa were obtained from the Manchester Consumption Hospital and thoroughly mixed. Four calves, which

had not been tested with tuberculin because of the possibility that tuberculin might prevent the disease, were inoculated—one in the lung, one subcutaneously, one intraperitoneally, and one was fed milk containing tuberculous sputum. The following results were reported: Calf No. 1, which received 5 c. c. of sputum mixture in the lung, died on the sixth day and showed on postmortem generalized tuberculosis which could not be referred to the inoculation. Calf No. 2, which received 5 c. c. of the mixture under the skin of the leg, died on the sixth day and showed enlargement of a gland 5 inches from the point of inoculation and no other trace of tuberculosis. Live virulent tubercle bacilli were found in the skin. Calf No. 3 received 50 c. c. of sputum mixture with its food in one day; died on the twenty-sixth day; tuberculosis of the esophageal glands, which contained virulent tubercle bacilli. Calf No. 4 received 5 c. c. of sputum mixture intraperitoneally. Twenty-six days after inoculation did not react to tuberculin; sixty-eight days after inoculation gave typical reaction; killed twenty days later and showed plainly tuberculosis of the peritoneum, spreading also to the pleura and pericardium. In addition, some lymph glands which were in relation with the peritoneum were tuberculous.

In these experiments only two calves lived long enough to give definite results. Both of these calves were affected with tuberculosis—one from feeding and the other from intraperitoneal injection with human tuberculous sputum. It must be admitted that the value of Delépine's work is very seriously affected by the fact that one of his calves died a few days after the beginning of the experiment of a recently developed generalized tuberculosis.

Hamilton and Young³⁵ for their experiments selected, first, calves varying in age from two days to ten weeks. The stall in which the animals were kept had never been occupied by cattle before. The experimental animals were fed upon milk, some meal, and a small amount of hay. The milk was obtained from cows which had not reacted to tuberculin, and every endeavor was used to avoid infection from the outside.

First experiment: Five calves were fed with milk containing human tuberculous sputum. Four of these animals were killed in from sixty-five to sixty-nine days after the beginning of the feeding and showed tuberculous changes in the retropharyngeal, mediastinal, and neck glands. The tuberculous character of the lesions was demonstrated by the presence of tubercle bacilli and giant cells and by the development of tuberculosis in guinea pigs which were inoculated with tissue. One of the calves died of septicemia thirty-seven days after the beginning of the experiment.

Second experiment: Four calves were inoculated subcutaneously with small fragments of a lymph gland taken from a tuberculous

human being. Three of these animals were killed in from sixty-six to eighty-seven days after the inoculation. One calf died twenty-two days after the beginning of the experiment. Of the first three, one remained healthy. The second showed tuberculous changes at the point of inoculation, in the neighboring lymph glands, and in the retropharyngeal and mesenteric lymph glands. In the latter case tubercle bacilli were found. In the fourth calf a number of lymph glands were diseased and isolated tuberculous areas were found in the lung. Another calf was inoculated subcutaneously with a fragment of lung taken from a man who had died of miliary tuberculosis. Eighty-seven days after the inoculation the animal was killed and tuberculous changes were noted at the point of inoculation, together with caseation of many lymph glands, and in addition two thickened areas at the base of the left lung. With the caseous material from the bronchial glands guinea pigs were made tuberculous. Finally, another calf was inoculated subcutaneously with urine containing tubercle bacilli which had been obtained from a man. This animal was killed fifty-five days after inoculation and showed enlargement and caseation of the retropharyngeal, mesenteric, and bronchial lymph glands and, in addition, tuberculous areas in the right lung.

Third experiment: Two calves were inoculated subcutaneously with fragments of tuberculous glands from men. In these cases also, when the animals were killed, more or less tuberculosis was found.

A third animal was inoculated subcutaneously with tuberculous sputum. After one hundred and fifty-five days it showed tuberculous bronchial and mesenteric glands. The point of inoculation seemed to be healthy. Two other calves which had been subjected twice to the tuberculin test and had not reacted inhaled tuberculous sputum and showed, one hundred and forty-five days later, marked tuberculosis of the lungs.

Fourth experiment: In order to ascertain what influence the passage of human tubercle bacilli from animal to animal would have upon the virulence of the microorganism, two calves were inoculated subcutaneously with material taken from another calf which had been previously inoculated with human tuberculous sputum. The experiment resulted in emaciation and loss of appetite of the animals. The autopsy showed generalized tuberculosis. As a result of the above experiments the authors reach the following conclusions:

Although the human tubercle bacillus is apparently not so virulent for calves as the bovine bacillus, yet it can infect cattle. The infection may be brought about by means of tuberculous sputum and tuberculous lymph glands or lung tissue. The disease may be brought about through intravenous or subcutaneous inoculations, through inhalation of pulverized sputum containing tubercle bacilli, or through feeding tuberculous sputum. In the case of feeding, the

abdominal lymph glands may become infected without visible lesions of the intestinal walls. The passage of the human tubercle bacillus through calves appears to heighten its virulence enormously. The authors, from the above experiments, are of the opinion that the human tubercle bacillus is identical with the bovine bacillus, although somewhat weaker in virulence.

The literature reviewed in the foregoing pages has been selected because of its special bearing upon the experiments we have made, and this review is not to be considered complete. For a fuller discussion of this subject, especially in its relation to public health, the reader is referred to Salmon's³⁶ report to the American Public Health Association on "Bovine Tuberculosis and Public Health."

BIBLIOGRAPHY.

- (1) KOCH, ROBERT.
An address on the fight against tuberculosis in the light of the experience that has been gained in the successful combat of other infectious diseases. *Brit. med. jrn.*, v. 2 for 1901, no. 2117, pp. 189-193. London, July 27, 1901.
- (2) KOCH, ROBERT, AND SCHÜTZ.
Menschliche tuberkulose und rindertuberkulose (perlsucht). *Arch. f. wissensch. u. prakt. thierh.*, bd. 28, hft. 1-2, pp. 169-196. Berlin, 1902.
- (3) KOCH, ROBERT.
An address on the transference of bovine tuberculosis to man. *Brit. med. jrn.*, v. 2 for 1902, no. 2190, pp. 1885-1889. London, Dec. 20, 1902.
- (4) DOBROKLONSKI, V.
De la pénétration des bacilles tuberculeux dans l'organisme à travers la muqueuse intestinale et du développement de la tuberculose expérimentale. *Arch. de méd. expér. et d'anat. path.*, sér. 1, t. 2, pp. 253-271. Paris, 1890.
- (5) NOCARD, ÉDOUARD.
Tuberculose. *Dict. pratique de méd. vét.*, t. 21, p. 508.—Cited by Isadore Straus, in *La tuberculose et son bacille*. 884 pp. il. 27^{cm}. Paris, 1895. (See pp. 362-363.)
- (6) CLAUSEN.
Beitrag zur uebertragung der tuberkulose vom menschen auf das schwein. *Ztschr. f. fl.- u. milchhyg.*, jahrg. 12, hft. 4, p. 115. Berlin, Jan., 1902.
- (7) TJADEN.
Rinder- und menschentuberkulose. *Deut. vierteljahresschr. f. öffent. gsndhtspf.*, bd. 34, hft. 3, pp. 366-392. Braunschweig, 1902.—*Revue. Rev. vét.*, ann. 28 (60), no. 5, pp. 289-290. Toulouse, April 1, 1903.—*Referat. Cent. f. bakt.*, abt. 1, Ref., bd. 32, no. 25, pp. 777-779. Jena, Feb. 19, 1903.
- (8) NOCARD, ÉDOUARD.
Ueber die uebertragbarkeit der rindertuberkulose auf den affen durch den genuss tuberkulöser materien. (Referat of paper read at Soc. de méd. vét. pratique, sitzung vom Mai 14, 1902.) *Schweizer arch. f. thierh.*, bd. 44, hft. 5, p. 241. Zürich, Sept.-Oct., 1902.
- (9) CIPOLLINA, ANGELO.
Beitrag zu dem studium der rinder- und menschlichen tuberculose. *Berl. klin. woch.*, jahrg. 40, no. 8, pp. 163-164. Berlin, Feb. 23, 1903.
- (10) RAVENEL, MAZICK P.
The passage of tubercle bacilli through the normal intestinal wall. A preliminary report. *Pub. health reports and papers, Am. pub. health assn.*, v. 29 for 1903, pp. 404-405. Columbus, 1904.
- (11) SCHOTTELIUS, MAX.
Versuche über fütterungs-tuberkulose bei rindern und kälbern. *Münch. med. woch.*, jahrg. 49, no. 39, p. 1610. München, Sept. 30, 1902.
- (12) HULS.
Zur frage der uebertragung der rindertuberkulose auf den menschen. *Münch. med. woch.*, jahrg. 49, no. 24, pp. 1003-1004. München, June 17, 1902.

- (13) HELLER, ARNOLD.
Kleine beiträge zur tuberkulose-frage. Münch. med. woch., jahrg. 49, no. 15, pp. 609-611. München, April 15, 1902.
- (14) BANG, B.
Die bekämpfung der rinder-tuberkulose. (Abstract of paper read at the Scandinavian veterinary congress in Copenhagen, 1902.) Berl. thierarztl. woch., no. 47, pp. 731-732. Berlin, Nov. 20, 1902.
- (15) ORTH, J.
Ueber einige zeit- und streitfragen aus dem gebiete der tuberkulose. II. Was ist perlsucht? Berl. klin. woch., jahrg. 39, no. 34, pp. 793-798. Berlin, Aug. 25, 1902.
- (16) FIBIGER, JOHANNES, AND JENSEN, C. O.
Uebertragung der tuberkulose des menschen auf das rind. Berl. klin. woch., jahrg. 39, no. 38, pp. 881-886. Berlin, Sept. 22, 1902.
- (17) KARLIŃSKI, JUSTYN.
Zur frage der uebertragbarkeit der menschlichen tuberkulose auf rinder. Oesterr. monatsschr. f. thierh., jahrg. 26, bd. 25, no. 11, pp. 481-493. Wien, 1901.
- (18) THOMASSEN.
La tuberculose de l'homme est transmissible aux bovidés. Ann. de méd. vét., ann. 50, no. 11, pp. 633-643. Bruxelles, Dec., 1901.
- (19) ARLOING, S.
Démonstration expérimentale de l'unité de la tuberculose. Jrn. de méd. vét., sér. 5, t. 7 (t. 54 de la collection), pp. 257-278. Lyon, May 31, 1903.
- (20) RAVENEL, MAZŮCK P.
The intercommunicability of human and bovine tuberculosis. Vet. jrn. (o. s., v. 55, no. 325), n. s., v. 6, no. 31, pp. 31-42, July; (no. 326), no. 32, pp. 93-104, Aug.; (no. 327), no. 33, pp. 140-147, Sept. London, 1902.—Univ. of Penn. med. bull., v. 15, no. 3, pp. 66-87. Philadelphia, May, 1902.
- (21) STENSTRÖM, OLAF.
Die tuberculose des menschen und der rinder. Ztschr. f. thiermed., bd. 6, hft. 4, pp. 289-291. Jena, 1902.
- (22) NOCARD, ÉDOUARD.
Sur les relations qui existent entre la tuberculose humaine et la tuberculose aviaire. Ann. de l'inst. Past., t. 12, no. 9, pp. 561-573. Paris, Sept. 25, 1898.
- (23) SVENSSON, JOSEF.
Untersuchungen über die tuberkulose bei menschen und rindern in Schweden Milch-zeitung, jahrg. 31, no. 25, pp. 390-391. Leipzig, June 21, 1902.—Referat. Ztschr. f. fl.- u. milchhyg., jahrg. 13, hft. 1, p. 18. Berlin, Oct., 1902.
- (24) DEAN, GEORGE, AND TODD, CHARLES.
Experiments on tuberculosis. Jrn. of path. and bact., v. 8, no. 4, pp. 458-489. Edinburgh and London, May, 1903.
- (25) DE JONG, D. A.
De eenheid der zoogdiertuberculose. p. 129. 4°. Leyden, 1902.—Revue. L'unicité de la tuberculose des mammifères. La sem. méd., ann. 23, no. 5, p. 40. Paris, Feb. 4, 1903.—Revue. Jrn. de méd. vét., sér. 5, t. 7 (t. 54 de la collection), pp. 102-103. Lyon, Feb. 28, 1903.
- (26) WOLFF, MAX.
Perlsucht und menschliche tuberculose. Berl. klin. woch., jahrg. 39, no. 46, pp. 1068-1070. Berlin, Nov. 17, 1902.
- (27) SMITH, THEOBALD.
Studies in mammalian tubercle bacilli. III. Description of a bovine bacillus from the human body. A culture test for distinguishing the human from the bovine type of bacilli. Trans. assn. Am. phys., v. 18, pp. 109-151. Philadelphia, 1903.

- (28) PARK, W. H.
Preliminary communication of experiments upon the feeding and inoculating of calves with human tuberculous material. *Proc. N. Y. path. soc.*, n. s., v. 1, no. 5-6, p. 111. New York, Oct.-Nov., 1901.—Referat. *Ztschr. f. fl- u. milchhyg.*, jahrg. 13, hft. 3, p. 92. Berlin, Dec., 1902.
- (29) MURSAJEV.
Ein beitrage zur charakteristik der menschen- und vögeltuberkulose. *Vestnik obshatsh. hig.*, etc., no. 9, pp. 1318-1335; no. 10, pp. 1439-1495. St. Petersburg. 1902.—Referat. *Fortschr. d. vet. hyg.*, jahrg. 1, hft. 3, pp. 122-123. Berlin, June, 1903.
- (30) KARLIŃSKI, JUSTYN.
Zur frage der uebertragbarkeit der menschlichen tuberkulose auf rinder. *Ztschr. f. thiermed.*, n. f., bd. 8, hft. 1-2, pp. 1-10. Jena, 1904.
- (31) FIBIGER, JOHANNES, AND JENSEN, C. O.
Uebertragung der tuberculose des menschen auf das rind. Zweite mittheilung. *Berl. klin. woch.*, jahrg. 41, no. 6, pp. 129-133, Feb. 8; no. 7, pp. 171-174, Feb. 15. Berlin. 1904.
- (32) KOSSEL, H.
Mittheilungen über versuche an rindern mit tuberkelbacillen verschiedener herkunft. *Berl. klin. woch.*, jahrg. 40, no. 20, pp. 653-657. Berlin, July 20, 1903.
- (33) DE HAAN, J.
Experimentelle tuberkulose. *Virchow's arch.*, bd. 174, hft. 1, pp. 1-14. Berlin, Oct. 2, 1903.
- (34) DELÉPINE, SHERIDAN.
The communicability of human tuberculosis to cattle. Preliminary communication. *Vet. jrn.* (o. s., v. 53, no. 317), n. s., v. 4, no. 23, pp. 309-313, Nov.; (no. 318), no. 24, pp. 349-352, Dec. London, 1901.
- (35) HAMILTON, D. J., AND YOUNG, J. M'LAUCHLAN.
[Zur verwandtschaft der tuberkulose des menschen und des rindes.] *Vet. rec.*, no. 779-780. London, 1903.—Referat. *Fortschr. d. vet. hyg.*, jahrg. 1, hft. 5, pp. 174-175. Berlin, Aug., 1903.
- (36) SALMON, DANIEL ELMER.
Reports on bovine tuberculosis and public health. U. S. Dept. of Agr., Bureau of animal industry, bul. no. 53. Washington, 1904.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ANIMAL INDUSTRY—BULLETIN NO. 53.

D. E. SALMON, D. V. M., Chief of Bureau.

REPORTS

ON

BOVINE TUBERCULOSIS AND PUBLIC HEALTH.

BY

D. E. SALMON, D. V. M.,

*Chairman of the Committee on Animal Diseases and Animal Food
of the American Public Health Association.*



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1904.

LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., November 21, 1903.

SIR: I have the honor to transmit herewith a manuscript entitled "Reports on Bovine Tuberculosis and Public Health," and recommend that it be published as Bulletin No. 53 of the Bureau series. The subject-matter of this manuscript is the annual reports on the relationship between bovine and human tuberculosis made to the American Public Health Association for the years 1901, 1902, and 1903 by me as chairman of the committee on animal diseases and animal food, a position which I have held during these years.

The first of these reports was published as Bulletin No. 33 of this Bureau, but the supply is about exhausted. It is included herewith because of the demand for all three reports from a class of people who will make the best possible use of the information given.

Respectfully,

D. E. SALMON,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary.

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BOVINE TUBERCULOSIS AND PUBLIC HEALTH.

INTRODUCTION.

Owing to the interest manifested in recent years in the subject of bovine tuberculosis, and particularly in the danger of its being communicated to mankind, it devolved upon the writer, as chairman of the committee on animal diseases and animal food of the American Public Health Association, to prepare and submit reports covering the essential points of this subject and presenting the most striking evidence in his possession. These reports are published herewith. The more important points embraced in the discussion are as follows:

- (1) Extent of bovine tuberculosis in Europe and the United States.
- (2) Effect of products of diseased animals upon the health of consumers, without reference to the direct transmission of a contagious disease.
- (3) The accidental infection of man by inoculation with bovine bacilli.
- (4) The infection of man by consuming the milk of tuberculous cows.
- (5) The results of scientific experiments with regard to the transmission of tuberculosis from man to bovine animals and vice versa.

The results of recent experiments, both in Europe and in the United States, demonstrate that quite frequently tuberculosis bacilli are found in the human subject which are virulent for bovine animals. It must be admitted, therefore, that either the human bacillus under certain conditions takes on an unusual virulence and is then practically identical with the bovine bacillus, or that these especially active bacilli have originated in cattle and caused disease in man. In either case the arguments which have been particularly urged during the last few years against the danger from bovine tuberculosis are shown to be weak and out of harmony with clearly established facts.

The development of our knowledge concerning this question has been rapid, and the facts brought together in these reports will give those interested in the subject a fairly clear idea of its present status.

D. E. SALMON.

BOVINE TUBERCULOSIS AFFECTING THE PUBLIC HEALTH. (First report.)^a

By D. E. SALMON, D. V. M.,

Chief of the Bureau of Animal Industry and Chairman of the Committee on Animal Diseases and Animal Food of the American Public Health Association.

Your committee on animal diseases and animal food has been impressed with the importance of the discussions which occurred at the recent British Congress on Tuberculosis concerning bovine tuberculosis and its effects upon the public health. Some of the opinions expressed at that congress have aroused the most extended interest among physicians and among laymen, and it seems appropriate that your committee should at this time review the subject at some length, in order to make clear what is already known, preparatory to taking steps definitely to settle contested questions by experimentation.

EXTENT OF BOVINE TUBERCULOSIS.

The extent and rapid increase of bovine tuberculosis in various countries has during recent years caused alarm, both because of its effects in reducing the general food supply and its supposed danger to human health.

The slaughterhouse statistics of Prussia show 14.6 per cent of the cattle and 2.14 per cent of the hogs to be tuberculous. In Saxony the percentage is 29.13 for cattle and 3.10 for hogs. In the city of Leipzig the figures are 36.4 for cattle and 2.17 for hogs. (Siedamgrotzky.) Of 20,850 animals in Belgium tested with tuberculin in 1896, 48.88 per cent reacted. (Stubbe.) Of 25,439 tested in Denmark from 1893 to 1895, 49.3 per cent reacted; and of 67,263 tested from 1896 to 1898, 32.8 per cent reacted. (Bang.) An examination of 20,930 cattle in Great Britain, either slaughtered and examined post-mortem or tested with tuberculin, showed 5,441, or 26 per cent, affected with tuberculosis. McFadyean estimates that 30 per cent of the cows in Great Britain are tuberculous.

Figures available in the United States do not cover a sufficient area of our territory to allow us to make a reliable estimate of the extent of tuberculosis with milch cows. There is little doubt, however, but that the disease has been increasing both with dairy cattle and hogs.

^a Report of committee on animal diseases and animal food to the American Public Health Association, at Buffalo, N. Y., September 16-20, 1901. Published also as Bulletin No. 33 of the Bureau of Animal Industry.

From a recent review by Russell and Hastings, of the Wisconsin Agricultural Experiment Station, of tests of cattle for tuberculosis which have been made in the United States, the following summary is presented:^{1 a}

Statistics of tests for tuberculosis in the United States.

State.	Number tested.	Number tubercular.	Per cent tubercular.
Vermont	60,000	2,390	3.9
Massachusetts	24,685	12,443	50.0
Massachusetts, entire herds	4,093	1,080	26.4
Connecticut	6,300		14.2
New York, 1894	947	66	6.9
New York, 1897-98	1,200	163	18.4
Pennsylvania	34,000	4,800	14.1
New Jersey	2,500		21.4
Illinois, 1897-98	929		12.0
Illinois, 1899	3,655	560	15.32
Michigan			13.0
Minnesota	3,430		11.1
Iowa	873	122	13.8
Wisconsin:			
Experiment station tests—			
Suspected herds	323	115	35.6
Nonsuspected herds	935	84	9.0
State veterinarian's tests—			
Suspected herds	588	191	32.5
Tests of local veterinarians under State veterinarian (cattle intended for shipment to States requiring tuberculin certificate)	3,421	76	2.2

The State veterinarian of Pennsylvania, Dr. Pearson, thinks that not over 2 per cent of the cattle of that State are tuberculous, and probably if a general test of all the cattle of the other States mentioned were made we should find a very much smaller proportion tuberculous than is indicated by this tabular statement. The explanation of the high percentages that have been given is found in the fact that it has been for the most part suspected herds which have been tested. Admitting that the greater part of these percentages are too high, they are still sufficient to demonstrate the wide distribution of tuberculosis and its comparative frequency.

Our beef cattle, as they come to the large packing houses, are yet comparatively free from tuberculosis. Of 4,841,166 cattle slaughtered in the year 1900 under Federal inspection, but 5,279, or 0.11 per cent, were sufficiently affected to cause the condemnation of any part of the carcass. Of 23,336,884 hogs similarly inspected, 5,440 were sufficiently affected to cause condemnation of some part of the carcass. This is equal to 0.023 per cent, or slightly more than one-fifth the proportion found in beef cattle.

^a References are to bibliography at end of bulletin.

The slaughterhouse statistics of all countries show that the percentage of affected hogs increases as the disease becomes more common in cattle, so that we must consider not only the effect of the disease upon beef and milk producing animals, but also upon hogs. The disease is more acute with hogs than with cattle, and there is a much greater tendency to generalization, and consequently the parts used for human food are more likely to be affected; and if there is a possibility of communicating the disease through the meat the danger is increased by this peculiarity of these animals.

EFFECT OF PRODUCTS OF DISEASED ANIMALS ON PUBLIC HEALTH.

Admitting, as we must, the increase of this disease among our food-producing animals, particularly cattle and hogs, it appears that this fact should cause concern from a public health standpoint irrespective of the question of the direct communicability of tuberculosis from animals to man. The people of the United States have always demanded meat from animals which were free from disease. Animal food has been so abundant and so cheap that even the poorer classes of our population have been able to use the best. There is no reason apparent at this time why there should be a departure from this rule and they be expected to consume the products of animals affected with tuberculosis. Animals so affected often have mixed infection, with high temperature, the formation of pus in different parts of the body, and particularly in the mammary glands, and there is undoubtedly in many cases a considerable development of toxins. The flesh of such animals must be affected in the same way as is that of animals affected with other fevers and septic conditions. The extensive development of tubercular lesions in the udder affects the secretion of milk, changes its composition, causes the secretion of great quantities of pus which are mixed with the milk, and leads to the development of a great variety of saprophytic germs which multiply in the milk and develop various decomposition products.

The consumption of food of this character has always been considered harmful, and especially so to children. It may seriously affect the digestion and cause diarrhea and other forms of illness by the toxins which are taken. It is extremely desirable that the source of our food supply should be guarded from contamination by disease and kept in as nearly a normal and healthy condition as possible. Every departure from this ideal state is a menace to the consumer and an injury to the public at large.

THE COMMUNICABILITY OF BOVINE TUBERCULOSIS TO MAN.

The important question as to whether bovine tuberculosis can be directly communicated to man has attracted considerable attention in this country for several years, and was discussed by the committee on

animal diseases and animal food at the last meeting. The conclusion had already been reached by some writers in this country that mankind was not susceptible to the form of tuberculosis which affects cattle. Now that this conclusion has been accepted and promulgated by Koch² in his address at the British Congress on Tuberculosis, and has been received so seriously by people generally as well as by the medical profession, it is deemed desirable to recapitulate what was said at that time and to add such further evidence and arguments as are available.

In this discussion we should never lose sight of the fact that, even if Koch's position is correct as to the insusceptibility of mankind to bovine tuberculosis—a conclusion which your committee believes is unwarranted by the evidence—and if it is admitted that it is unnecessary to adopt measures against the bovine disease in the fight against human tuberculosis, it does not follow, by any means, that the products of these diseased animals are harmless and should be allowed to go into consumption. Nevertheless, Koch's conclusion is being used already as an argument and excuse for the sale of tuberculous meat and milk. This discussion as to the communicability of bovine tuberculosis should not be allowed to obscure the general question of the importance of condemning meat and milk of diseased animals, whether the disease is or is not a specific one which may be communicated to the consumer of these products. There is no argument to justify the sale of milk secreted by tuberculous udders, reeking with pus and the microorganisms which it contains, changed in its chemical composition, and unsavory to every civilized person. The question of the desirability of measures against bovine tuberculosis as a part of the campaign against human tuberculosis is a thing by itself and entirely distinct from the desirability of such measures from an economic and general public-health standpoint.

Whenever this question is discussed in medical meetings or medical journals the general excuse for a toleration of the present condition of affairs is that the danger from bovine tuberculosis has been greatly exaggerated. Quite likely it has been exaggerated by some individuals, but it has just as certainly been underestimated by others. What has been the effect of the discussions heretofore held? Have the public been too much alarmed? Have sanitarians gone to too great extremes? Have we anywhere a too rigid meat inspection or a too careful supervision of the milk supply? If so, your committee is not aware of the fact. And, until this occurs, the repetition of the statement that the danger from bovine tuberculosis has been exaggerated appears to be entirely superfluous and useless.

Koch in his recent paper makes two radical assumptions: First, human tuberculosis differs from bovine tuberculosis, and can not be communicated to cattle; second, mankind is nearly, if not absolutely, insusceptible to bovine tuberculosis. It is incumbent upon us to

examine the evidence upon which these propositions rest, for if they can be demonstrated the fact would be welcomed by every sanitarian, not because it would no longer be necessary, for economic and public health reasons, to control bovine tuberculosis, but because it would prove that some dangers which we have hitherto feared do not exist, and it would simplify the measures needed in the warfare against human tuberculosis. We should not allow ourselves, therefore, to be biased by preconceived opinions, but should honestly and conscientiously weigh all evidence that is presented.

Neither of these propositions is original with Koch, but this is probably the first time that a scientific man of such standing and authority has ventured to adopt them. Sidney Martin, in his experiments for the British Royal Tuberculosis Commission of 1895, showed that sputum from man was far less virulent for animals than was bovine tubercular material. Theobald Smith, Frothingham, and Dinwiddie have repeated these experiments with cattle and other animals and incontestably demonstrated this conclusion. It does not appear to be entirely correct, however, to say that human tuberculosis is not communicable to cattle. It would be more accurate to say that in the experiments referred to human tuberculosis was only communicated with difficulty to cattle, and when it was communicated it remained localized and did not cause a fatal disease.

Of 6 calves to which sputum was fed by Martin, 2 showed no lesions, 1 had 53, 1 had 63, and 2 had 13 tubercular nodules, respectively, in the intestines. In 1 of these animals the mesenteric glands were also affected. Smith also produced small lesions in some of the animals with which he experimented. The failure to cause fatal disease in cattle with sputum bacilli appears to be due to lack of virulence, or, we might say, to low pathogenic power, rather than to any essential difference in bacilli from human and bovine sources. This is shown by the fact that human bacilli were less active, not only when inoculated upon cattle, but also when inoculated upon other species of animals.

The experiments of Chauveau,³ which were made prior to those mentioned above, are more conclusive and can not be ignored in discussing this question. In one series of experiments he infected 2 heifers and a bull, all under 1 year old, with emulsions made from tuberculous human lungs. These infections were by ingestion, but two doses being given to each animal. One of the heifers, killed 57 days after infection, had more than 200 tubercles of different sizes in the small intestines. There were also tubercles in the cecum, colon, abomasum, liver, and peritoneum. The autopsy on the second heifer occurred 59 days after infection. In this case the abdominal lesions were insignificant, consisting of two or three follicular hypertrophies in the jejunum and a few small tubercular mesenteric glands. The right submaxillary gland and the two retropharyngeal glands were enlarged and affected with

typical tubercular infiltration. The lungs showed not less than 12 tuberculous centers, most of them the size of a walnut, and near these masses were points where tubercular infiltration was beginning. All the bronchial and mediastinal glands were enlarged, tuberculous, and infiltrated with gray and yellow matter. The bull was destroyed on the thirty-fourth day. There was a plain tuberculous eruption in the small intestine, some portions of the mucous membrane, particularly on the Peyer's patches, being covered with confluent tubercles. In the left lung there was a single tuberculous nodule of considerable size, and some lobules presented a gelatinous appearance and consistency. There were aggregations of small tubercles in the larynx and upper part of the trachea, some of which were already ulcerated. There were also tubercular granulations in the bronchi. At the time these animals were infected, 3 similar animals were infected in like manner with bovine material, and 3 others were held as checks. The latter were found free from tuberculosis. At the autopsy it was impossible to distinguish any difference between the animals infected with human and those with bovine material. All were affected, and with all the tuberculous lesions had the same characters.

Chauveau, also, made comparative experiments by intravenous injection and subcutaneous inoculation; from all of these he concluded that the human tuberculous virus acts on the bovine species exactly like the tubercular virus which comes from the bovine species itself.

That the diseases are not absolutely distinct is indicated by the fact that tuberculin made from human bacilli causes a reaction in cattle affected with bovine tuberculosis. The Bureau of Animal Industry has distributed hundreds of thousands of doses of tuberculin made from human bacilli, and this tuberculin has been used by State authorities in various parts of the United States for diagnosing the disease in cattle, and has been found extremely reliable and satisfactory for this purpose. This fact would clearly indicate that if there is a difference between bacilli from human and bovine sources—and your committee is inclined provisionally to admit such a difference—it consists in minor biological variations and not in the germs being specifically distinct.

In discussing the susceptibility of man to bovine tuberculosis, it appears to your committee that Koch has simply begged the question. Even if we admit that human tuberculosis is not readily communicable to cattle, the conclusion that bovine and human tuberculosis are entirely different and not intercommunicable between these species does not necessarily follow. Another possible conclusion, and one more in harmony with what is known of comparative pathology, is that the bovine bacillus, being proved more virulent for all animals upon which it has been tried, is also more virulent for man.

As pointed out in this committee's report of last year, there is no contagion which affects so many and such widely separated species of

animals as does the bovine bacillus and which is not at the same time pathogenic for man. Bovine tuberculosis is communicable to horses, cattle, sheep, hogs, dogs, cats, guinea pigs, and rabbits. This is a very extensive range of pathogenic power. What other pathogenic germ is there which is virulent for so many and such widely separated species and which is not virulent also for man?

As examples of diseases which affect many species of animals, we have anthrax, rabies, glanders, malignant edema, and tetanus, to all of which mankind is susceptible. As examples of diseases which affect a fewer number of species, we have epizootic aphtha, which principally affects cattle and hogs, and which is communicable to man; we have vaccinia, or cowpox, which affects horses and cattle and which is communicable to man; we have rinderpest, which affects only ruminants and which is not communicable to man; we have pleuropneumonia and Texas fever, which affect cattle and are not communicable to man; and we have sheep pox, which affects sheep only, and hog cholera affecting hogs only, which are not communicable to man. The rule appears to be that the larger the number of animal species susceptible the more likely is a contagion to affect man. Surely a germ which is pathogenic for so many species of animals as is the bovine tubercle bacillus should be considered as dangerous to man until positive evidence has proved its innocence.

We are not without parallel cases in comparative pathology which should be considered in deciding such an important question. One of these is found in rabies. When the contagion of this disease is inoculated into monkeys and passed from one animal of this species to another for a few times, the virus, as is well known, becomes so lacking in pathogenic power that it no longer produces rabies in dogs when inoculated in the usual manner. It must be apparent to all how wrong it would be to conclude that because rabies of monkeys is not communicable to the dog, conversely the rabies of the dog is not communicable to monkeys; yet this appears to be exactly the kind of assumption which Koch has made in regard to the bovine tubercle bacillus.

Another parallel case is found in variola. The variola of man, commonly called smallpox, is conveyed to cattle with much difficulty. Like human tuberculosis, it produces, when inoculated in these animals, only insignificant results when compared with the disease in man, with no tendency to generalization or to the production of fatal results, but, on the other hand, the tendency is to retrogression and healing. Nevertheless, the bovine variola, known as vaccinia, or cowpox, is easily inoculated upon man, develops to the same extent as in cattle, produces characteristic lesions, runs its regular course, and may be transferred from man to man an indefinite number of times, as has been shown in the practice of vaccination. If cowpox had

never been experimentally tested upon man, and we had only the results of experiments in inoculating smallpox upon cattle, we should have the same reason for concluding that vaccinia is not communicable to man that has been cited in the case of tuberculosis.

Koch alludes to two kinds of evidence available for deciding this question: First, the demonstration of cases of primary intestinal infection in man; secondly, the inoculation of cattle with bacilli found in cases of human tuberculosis. It appears to your committee that his treatment of this question is very narrow and unsatisfactory. In deciding as to the susceptibility of man the evidence now available may be classified under four heads: (1) Accidental inoculations with bovine bacilli; (2) clinical evidence of individuals infected by use of milk; (3) statistics of abdominal tuberculosis; (4) results of post-mortem examinations. We shall discuss the subject under these four heads.

ACCIDENTAL INOCULATIONS OF MAN WITH BOVINE BACILLI.

The first and most important line of evidence is that obtained from accidental inoculations of man with bovine bacilli. Ravenel⁴ has put on record three cases of veterinarians in the State of Pennsylvania who were accidentally inoculated with bovine tuberculosis in making post-mortem examinations. Case 1 was accidentally wounded in the knuckle of his forefinger. The wound healed badly and a nodule soon formed which showed a decided tendency to ulcerate. After some weeks he had the nodule removed, and a section of the excised portion was found to contain a large giant cell, but tubercle bacilli were not satisfactorily demonstrated in the preparation. The nodule recurred after excision and was finally cured by treatment in the hot-air apparatus. Case 2 was Ravenel's assistant, who scratched his knuckle on the broken end of a rib in performing a postmortem on a goat which had succumbed to an experimental inoculation with a culture of bovine tubercle bacillus. The wound healed promptly, but about 3 weeks afterwards became reddened, swollen, and sensitive. It grew worse and was finally excised with a margin of healthy skin. Two guinea pigs were inoculated subcutaneously with a portion of this nodule and both developed a generalized tuberculosis. Case 3, a well-known veterinarian of Philadelphia, wounded the knuckle of his forefinger in making an autopsy on a tuberculous cow. Between 3 and 4 weeks afterwards the scar was noticed to be enlarged, reddened, and somewhat sensitive. As it showed no tendency to improve, but rather grew worse, it was excised some 6 weeks after the inoculation and the wound cauterized with bromine, since which there has been no return. The nodule was examined by Dr. John Guiteras, who demonstrated its tuberculous nature by finding tubercle bacilli in sections.

L. Pfeiffer⁵ cites the case of Veterinarian Moses, 34 years old, of healthy family and personally in good health, who pricked his left thumb in making an autopsy on a tuberculous cow. The point of the knife probably penetrated into the articulation of the first and second phalanges. The puncture healed without suppuration, but at the end of 6 months there formed at the cicatrix a cutaneous tubercle, and the joint was removed. Soon afterwards the patient began to cough, and died of phthisis 18 months after the accident. On opening the articulation of the thumb it was found filled with caseous masses extraordinarily rich in tubercle bacilli.

A somewhat similar case occurred in the practice of M. B. Hartzell, of Philadelphia, and was partially reported at the meeting of the American Medical Association, held at Philadelphia June 1 to 4, 1897. Further details have been received through Ravenel. The patient, a man in excellent health and weighing 175 pounds, was employed by a railroad company to clean cars used for the transportation of cattle. He was wounded upon the back of the hand by a piece of broken wood-work of a car, and typical verrucous tuberculosis developed locally. This was apparently successfully treated by Hartzell. Within a year the patient's general health changed greatly; he was emaciated, had a persistent cough with abundant expectoration, and there was a decided dullness at the left apex, with numerous râles. Death soon resulted from general tuberculosis.

A very interesting case of "primary subcutaneous tuberculosis," caused by the topical application of cream, was reported by Grothan.⁶ A little girl 6 years old had suffered from an eruption on the left leg, supposed to be due to ivy poisoning. This was treated at home by the topical application of fresh cream. When seen by Grothan there was a painless ulcer of irregular shape the size of a 25-cent piece on the posterior aspect of the leg, having the characteristic appearance of a tubercular ulcer, with reddish tinged borders slightly overhanging the floor, which was covered with granulations and watery pus. There were also about a dozen light-mahogany colored spots confined to the calf of the leg and the lower third of the thigh, varying from the size of a hazelnut to the half of a large walnut, and containing masses of caseous material. The cow was examined and the udder seemed normal, yet inguinal and intraperitoneal inoculation of two rabbits with a mixture of milk and cream gave positive results in both inguinal inoculations and one peritoneal. The caseous material from the nodules of the girl's leg injected into the peritoneum of a rabbit produced tuberculous peritonitis and death in about 3 weeks. The family was using milk from one cow only at the time the application was made.

A somewhat similar case was recorded by Coppez.⁷

A girl 17 years old had a wound on the palmar aspect of the third finger between the second and third phalanx, which became infected with tubercle bacilli during

milking. The original lesions gave rise, within 6 months, to over 35 subcutaneous abscesses situated in different parts of the body. There were 2 on the right hand, 4 on the elbow, 2 on the shoulder blade, several on the right cheek, 2 on the left palm, 1 on the back of the neck, a dozen on the buttocks and thighs, 4 on the left leg, 3 on the sole of one foot, and 1 on the big toe. Most of these were curetted and iodoform applied 6 months after the beginning of the disease. Subsequently more appeared—in all from 60 to 66. The author describes the appearance of these foci as follows:

At a certain point, always in the neighborhood of a preexisting focus, a thickening of the subcutaneous tissue appeared, associated with increased heat of the skin and pain on pressure. The heat soon disappeared and a fluctuating livid tumor opened itself and discharged pus, and later a yellowish serum. These various abscesses healed slowly, and within a year all disappeared. At no time could any visceral lesions be recognized, but one eye became involved. The nature of the affection was demonstrated by inserting some pus from an abscess into the eye of a rabbit. There was but slight reaction at first. Subsequently the whole eye became diseased, the lymph nodes of the neck being greatly enlarged. After several months death ensued.

A third case of tuberculosis communicated by inoculation with infected milk was reported by Priester.⁵

A young man employed on the docks tried to remove a number of tattoos from his hands and forearms by introducing milk into the tattooed parts by means of needle punctures. This operation was repeated several times. Later there appeared on the back of both hands, at points which had been treated on the same day, bright red spots the size of millet seeds, containing a yellow center. Pus was evacuated from several nodules. These were found to be lupus nodules (tuberculosis of the skin) in which giant cells were demonstrated. The diseased parts were cut out and the wounds healed without a recurrence of the trouble.

Tscherning,⁹ of Copenhagen, treated a veterinarian whose finger had been wounded in making a postmortem examination of a tuberculous cow. Three weeks after the accident, the slight wound having already healed, the surrounding tissues became swollen, and a little later a suppurating ulcer formed. Notwithstanding an appropriate treatment, the local disease became worse and it was necessary to excise all of the swollen tissue. Microscopic examination demonstrated tubercles with bacilli. The patient recovered without further development of the disease.

M. T. Naughton, Chicago, Ill., has communicated to this committee the following case, which was observed in his practice:

G. E. W., Pole; age, 34; weight, 170 pounds; healthy looking man; butcher by occupation. Family history negative. Father of three healthy children. Has no recollection of having been previously sick. On May 3, 1899, while cleaning cattle viscera, he fell and a stationary meat hook upon which hearts and lungs are hung penetrated through the right hand between the second and third metacarpal bones. A tendo vaginitis resulted, with some lymphangitis of the arm. He received the usual treatment for an infected wound and apparently made a good recovery, with, however, some limited motion of the fingers and a sensitive scar at the site of puncture. Four months afterwards an abscess formed in the axilla, which was cleaned out and tubercle bacilli were demonstrated in the broken-down gland tissue. At this time there was no soreness in the arm lymphatics or elbow gland, but he complained that there had been. In 3 months afterwards, or 7 months from the original accident, he died from pulmonary tuberculosis.

These are very clear cases and could be multiplied if necessary to add strength to the evidence. These cases demonstrate the susceptibility of man to infection by bovine bacilli inoculated into the skin or subcutaneously. Not only were local lesions produced, but in some cases the disease was generalized and ended in death. The value of such cases of inoculation in demonstrating the susceptibility of man has been questioned on the ground that the lesions resulting from inoculation of the skin are usually slight and remain localized. While it is true that they remain localized in most cases, they have sometimes been attended by fatal results, and in all cases appear to be at least as serious as similar inoculations with the human bacillus. The human bacillus is known to be pathogenic for man and it causes one of the most fatal of human diseases. Now, if the bovine bacillus, when inoculated in the skin, produces at least as serious results as the human bacillus we have a right to conclude that mankind is equally susceptible to the bovine as to the human form of contagion.

It is reported that one of the foreign delegates said in the British congress that the inoculation of man from animals is a different thing from infection by way of the alimentary tract. While this may be admitted, it is nevertheless true that the human bacillus, which may infect man by way of the alimentary tract, is only inoculated in the skin with difficulty, as is shown by the insignificant lesions which usually follow inoculations in making autopsies and dissections. In other words, the alimentary tract appears to be a more favorable route of entrance for the human bacillus than is the skin, and consequently if the bovine bacillus is able to enter the body by means of skin inoculations, there is every reason to believe that it may also enter by way of the alimentary tract.

These very clear cases appear to demonstrate the communicability of bovine tuberculosis to man and to indicate that the bacilli from a bovine source are at least as virulent for man as are bacilli from a human subject. It will not do to put these cases aside, saying that such inoculations are another matter from intestinal infection, because the great point to be decided is the susceptibility of man to the bovine bacillus; and it will be observed that Koch proposes in testing the virulence of bacilli from the human subject to do this by subcutaneous inoculations in cattle. If such inoculations are a proper test of susceptibility in the one case why are they not equally so in the other?

TUBERCULOSIS IN MAN BELIEVED TO HAVE BEEN CAUSED BY INGESTION OF MILK FROM TUBERCULOUS COWS.

The second class of evidence to which your committee would refer is the clinical observation of individuals infected by the ingestion of milk. One of these frequently cited is a case reported by Ollivier to

the Paris Academy of Medicine.¹⁰ Twelve girls contracted tuberculosis in a young ladies' boarding school. Of these 5 died. From the fact that the sick and deceased girls were descended from healthy ancestors and, above all doubt, showed the phenomena of intestinal tuberculosis, there was suspicion of infection with the food. Full confirmation of this suspicion was found in the slaughter of a cow which for a year had served as a source of milk supply for the school. The cow had extensive tuberculosis of the intestines and udder. This case has particular value because of the number of persons affected, the fact that they had intestinal tuberculosis, and the demonstration of udder tuberculosis in the cow.

Another case is cited by T. Percy C. Kirkpatrick.¹¹ This was the case of a daughter of a Dr. Gosse, of Geneva, reported by himself. The girl up to the age of 17 had been quite healthy and had no history of hereditary taint or predisposition to tuberculosis. Early in 1893 she became ill, with more or less vague and undefined symptoms, and died in some 10 months. Gosse performed a postmortem examination, and discovered extensive tuberculosis of the mesenteric glands and abdominal viscera. When trying to find the source of infection in this case, Gosse's attention was drawn to a small farm which he possessed in the country and which he had been accustomed to visit on Sundays with his daughter, and one of her chief delights was to drink milk from the cows there. On examination 4 of the 5 cows were tubercular and 2 had disease of the udder.

An interesting case was under the care of Thomas M. Rotch in the Children's Hospital, in Boston, in 1893 or 1894. The particulars were sent to Dr. de Schweinitz, of the Bureau of Animal Industry, by Rotch. A boy 7 years old had been drinking a great deal of milk from one cow for about 4 months before entering the hospital. The cow was found to be tuberculous, the disease being demonstrated by autopsy. The boy was a case of primary tubercular peritonitis, with effusion. Laparotomy was performed by Dr. Bradford, and a large amount of serous fluid evacuated. The peritoneum was found to be thickly studded with minute tubercles, and the presence of tubercle bacilli was demonstrated. Four years after the operation the boy was found to be perfectly well and seemed free from tuberculosis.

Lydtin¹² gives the following case: Dr. Stang, of Amorbach, was called to a finely developed 5-year-old boy, the son of healthy parents, with no hereditary taint in their ancestors. The boy died a few weeks later with miliary tuberculosis of the lungs and enormously enlarged tubercular mesenteric glands. At the necropsy it was learned that the boy had habitually drunk the milk of a cow which had been killed shortly before he died and which had shown pulmonary tuberculosis.

Mr. Howe, of North Hadley, Mass., lost a son 20 months old from abdominal tuberculosis 3 months after he paid a week's visit to his

uncle and had been fed with milk of the uncle's cow. The cow was killed soon afterwards and proved to have generalized tuberculosis. The child's sickness and wasting began a few weeks after he returned home. He had previously been strong and healthy, as were and are his parents.¹³

A 4-year-old son of Colonel Beecher, of Yonkers, and grandson of Henry Ward Beecher, died March 4, 1894, of tubercular meningitis, and the two Alderney cows which supplied him milk were proved tuberculous by the tuberculin test and postmortem examination. There was no hereditary taint.¹³

A Scotch family, strong and healthy, had a herd of cows which contracted tuberculosis. Two young daughters brought up on the milk died of tuberculosis, while 2 older brothers, using little or no milk, remained well and hardy.¹⁴

Dr. Demme,¹⁵ chief physician of the Children's Hospital, Berne, records the cases of 4 children, born of healthy parents and without tuberculous ancestors either on the paternal or maternal side, who died of intestinal and mesenteric tuberculosis, having consumed for some time milk furnished by tuberculous cows. Among 2,000 tuberculous children treated by Dr. Demme in 20 years, these were the only ones in which he could absolutely exclude the possibility of hereditary taint and all other causes of the disease except milk infection.

Von Ruck¹⁶ records the following case, which he considers almost conclusive:

M., age 33, weight 180 pounds, was treated by his family physician about 6 weeks for what was supposed to be typhoid fever. Growing worse when convalescence was looked for, Von Ruck was called in consultation. Diagnosis of acute miliary tuberculosis was soon established. The autopsy showed the usual dissemination of the tubercular process, but no old focus was found in chest or abdomen, which only were permitted to be examined. Family and personal history good; and the source and mode of infection remained for the time obscure.

A few days after M.'s death, Von Ruck was called to see his nearly 1-year-old child on account of fever and diarrhea, which yielded to treatment, but the child did not recover its former good health. Gradually symptoms of meningitis developed and the child died. No postmortem was permitted, but there was no doubt of the tubercular character of the meningitis. Infection from father was not probable, the child having been removed from the house at an early period of his illness.

The milk which the child had received came from a Jersey cow, and no other had been used up to the time the diet was changed on account of the diarrheal attack. The father had drunk largely of this cow's milk, taking a pint and sometimes a quart twice a day, warm, at the time of milking, and this cow's milk was given him exclusively during his entire illness. On examination one of the cow's teats was found to be shrunken; it was said to yield little milk, and several months before the milk was occasionally bloody. There was a hard, irregular lump on the same side of the udder. When the cow was killed, several months later, there was found extensive tuberculosis in the lungs and peritoneal cavity, and the lump in the udder contained a caseous center, which on examination showed numerous well-stained tubercle bacilli.

These are examples of clinical evidence which might be greatly extended, but all are, of course, open to the objection that we do not know absolutely that the disease was caused by the bovine bacillus. However, the occurrence of abdominal tuberculosis soon after the use of milk from tuberculous cows is a coincidence which justifies us in accepting the cases as strong circumstantial evidence, not of themselves demonstrating the communicability of bovine tuberculosis, but, taken with other evidence, making a case which it is difficult to contest.

STATISTICS SHOWING FREQUENCY OF ABDOMINAL TUBERCULOSIS.

The third line of evidence to which we invite attention is the statistical data available from various parts of the world.

Thorne, in the Harben lectures for 1898, shows from the statistics of England and Wales that between the periods 1851-1860 and 1891-1895 there has been a reduction of the mortality at all ages from phthisis of 45.4 per cent, while from all forms of tuberculosis the reduction has been distinctly less, namely, 39.1 per cent. Taking that form of disease registered under the name of "*tabes mesenterica*," the reduction at all ages has been but 8.5 per cent; under 5 years of age the reduction has been but 3 per cent; while under 1 year of age there has been an actual increase of 27.7 per cent. This is the milk-drinking age, and the increase of the mortality is very significant at a time when phthisis has been so remarkably reduced. So instructive are these statistics that we reproduce here Thorne's table showing the mortality from this disease:

England and Wales—Mortality from tabes mesenterica in several periods, 1851-1895.

Period.	Per million living (all ages).	Per million births (under 1 year).	Per million living (under 5 years).
1851-1860.....	260	3,169	1,625
1861-1870.....	295	3,800	1,856
1871-1880.....	318	4,467	2,028
1881-1885.....	289	4,356	1,852
1886-1890.....	265	4,462	1,764
1891-1895.....	238	4,016	1,577
Reduction or increase per cent between 1851-1860 and 1891-1895..	-8.5	+27.7	-3.0

The conclusions which naturally follow from these statistics are so different from the opinions of many men that numerous attempts have been made to counteract them. Some have held that the cases returned under "*tabes mesenterica*" could not be relied upon as abdominal tuberculosis. An examination of the evidence presented leads your committee to the conclusion that this point is not well taken.

Still¹⁷ has recorded the results of 769 autopsies on children under 12 years of age at the Hospital for Sick Children, Great Ormonde

street. Two hundred and sixty-nine cases were found showing tuberculous lesions. In those in which the channel of infection could be made out with some certainty the primary infection was as follows: Lung, 105; intestine, 53; ear, 9; bones or joints, 5; that is, the intestinal infections were to the others as 1 to 2.1. With the class of cases where death was caused by some other disease and where tuberculosis either was arrested in an early stage or had not progressed beyond the initial stage, affording almost indisputable evidence of the methods of infection, the infections were thus: By the lung, 26; by the intestine, 16; by the ear, 1. Here the intestinal infections were to the others as 1 to 1.7. In the English statistics the cases of *tabes mesenterica* in children of 5 years and under are to the other forms of tuberculosis as 1 to 1.6. Still's observations are, therefore, a singular indorsement of the accuracy of the returns under the name of *tabes mesenterica*, and as the ages of the children covered by his autopsies were 12 years and under, he has really found a larger percentage of intestinal infection than is indicated by the statistics.

Also J. Walter Carr¹⁸ refers to statistics of necropsies on tuberculous children at the Victoria Hospital. He found 79 in which the disease most probably started in the chest and 20 in which it seemed to have begun in the abdomen. Here the relation between the two forms of infection is 1 to 4. In 26 children with early or limited tuberculosis, the thorax was alone affected in 12 cases and the abdomen in 7, being in the proportion of 1 to 1.7. Of 53 tuberculous children under 2 years of age the disease most probably began in the chest in 43, and in only 5 certainly in the abdomen, the proportion in this case being as 1 to 8.4. Out of 25 children over 5 years of age the disease began in the chest in 12 and in the abdomen in 6, the relation being as 1 to 2.

Shennon¹⁹ collected data from postmortem examinations at the Royal Hospital for Sick Children, Edinburgh, of 355 cases of tuberculosis, in 331 of which he was able to determine the channel of infection. In 67.7 per cent it was respiratory, in 28.1 per cent it was alimentary. This is as 1 to 2.3.

These postmortem examinations, all from English sources, may be accepted as fairly representative of the results of the postmortem room, and they sustain Thorne's contention that the returns in England of *tabes mesenterica* represent with reasonable accuracy the abdominal tuberculosis of children in that country. It may be added that in Still's most recent paper²⁰ he states that "it would seem, therefore, that, at any rate among hospital patients in London, nearly one-third of the child mortality is due to tuberculosis; and although such an estimate may, for various reasons, be too high when applied to the whole child mortality of this city, it seems almost certain that the average given by the registrar-general's statistics is far too low. During the 5 years

1891 to 1895 the average number of deaths per annum from all causes among children up to the age of 10 years in this city was 36,349; out of these the average number of children certified each year as having died of tuberculosis was 3,335. The evidence of postmortem statistics makes it practically certain that a very much larger number than this died of tuberculous diseases, and probably we should be well within the mark if we said that at least 6,000 children die every year in London alone from tuberculosis." This being the case, and the proportion between *tabes mesenterica* and other forms of tuberculosis remaining the same, there must have been nearly twice as many cases of intestinal tuberculosis in London as were recorded by the registrar-general; but as *tabes mesenterica* is one of the most obscure forms of the disease, the probability is that more children affected with this form of tuberculosis were otherwise reported than was the case with phthisis, tubercular meningitis, and other forms of tuberculosis that were more easily diagnosed. At any rate, it may be accepted as certain that the evidence so far presented has sustained Thorne's conclusions in regard to *tabes mesenterica*. This being the case, your committee deems it advisable to introduce at this point the statistics of England and Scotland and some of the principal cities of the world, showing deaths from different forms of tuberculosis.

Deaths from tuberculous diseases in England and Wales for the year 1898.

[Population 31,397,078.]

Form of disease.	Under 1 year.	Under 5 years.	Under 10 years.	Under 15 years.	Under 20 years.	Under 25 years.	Under 35 years.	All ages.
<i>Tabes mesenterica</i>	3,265	5,050	5,369	5,555	5,725	5,850	6,050	6,357
Tubercular meningitis (acute hydrocephalus).....	1,985	4,904	5,791	6,147	6,339	6,451	6,573	6,681
Other forms of tuberculosis, scrofula.....	1,319	2,585	3,085	3,399	3,851	4,233	4,807	5,766
Total other than phthisis.....	6,569	12,539	14,195	15,101	15,915	16,534	17,430	18,804
Phthisis.....	493	1,491	2,126	3,127	6,437	11,212	21,007	41,335
Total tuberculosis.....	7,062	14,030	16,321	18,228	22,352	27,746	38,437	60,139

Deaths from tuberculous diseases in Scotland for the year 1898.

[Population 4,249,946.]

Form of disease.	Under 1 year.	Under 15 years.	Under 25 years.	All ages.
<i>Tabes mesenterica</i>	239	788	872	947
Tubercular meningitis.....	350	1,212	1,263	1,288
Other forms of tuberculosis, scrofula.....	121	459	605	815
Total other than phthisis.....	710	2,459	2,740	3,050
Phthisis.....	78	720	2,675	7,090
Total tuberculosis.....	788	3,179	5,415	10,140

Deaths from tuberculous diseases in London for the year 1898.

[Estimated population, 4,504,766.]

Form of disease.	Under 1 year.	Under 5 years.	Under 10 years.	Under 15 years.	Under 20 years.	Under 25 years.	Under 35 years.	All ages.
Tabes mesenterica	602	838	884	903	915	930	958	997
Tubercular meningitis	397	989	1,128	1,177	1,197	1,213	1,232	1,250
Other forms of tuberculosis, scrofula	285	555	639	693	750	791	865	983
Total other than phthisis	1,284	2,382	2,651	2,773	2,862	2,934	3,055	3,230
Phthisis	98	308	385	496	851	1,517	3,272	7,812
Total tuberculosis	1,382	2,690	3,036	3,269	3,713	4,451	6,327	11,042

Deaths from tuberculous diseases in Berlin for the year 1898.

[Population, June 30, 1,768,624.]

Form of disease.	Under 1 year.	Under 5 years.	Under 10 years.	Under 15 years.	Under 20 years.	Under 25 years.	Under 35 years.	All ages.
Tabes mesenterica	4	14	23	29	30	35	45	71
Tubercular meningitis	39	163	196	205	210	216	225	237
Other forms of tuberculosis, scrofula	20	34	38	40	40	47	62	88
Total other than phthisis	63	211	257	274	280	298	332	396
Phthisis	78	246	300	360	559	983	1,867	3,558
Total tuberculosis	141	457	557	634	839	1,281	2,199	3,949

Deaths from tuberculous diseases in Paris for the year 1897.

[Population, 1896, 2,511,629.]

Form of disease.	Under 1 year.	Under 5 years.	Under 10 years.	Under 15 years.	Under 20 years.	Under 25 years.	Under 35 years.	All ages.
Tabes mesenterica	4	21	34	47	55	61	83	154
Tubercular meningitis	140	633	802	837	857	892	943	999
Other forms of tuberculosis, scrofula	50	143	174	196	248	346	567	1,168
Total other than phthisis	194	797	1,010	1,080	1,160	1,299	1,593	2,321
Phthisis	48	244	325	456	1,038	1,955	4,296	9,298
Total tuberculosis	242	1,041	1,335	1,536	2,198	3,254	5,889	11,619

Deaths from tuberculous diseases in New York City for the year 1899.

[Estimated population, 3,550,053.]

Form of disease.	Under 1 year.	Under 5 years.	Under 10 years.	Under 15 years.	Under 20 years.	Under 25 years.	Under 35 years.	All ages.
Tabes mesenterica	34	40	40	40	40	40	42	45
Tubercular meningitis	281	676	750	766	781	795	819	864
Other forms of tuberculosis, scrofula	79	175	211	233	272	328	437	613
Total other than phthisis	394	891	1,001	1,039	1,093	1,163	1,298	1,522
Phthisis	98	220	269	362	778	1,751	4,316	8,015
Total tuberculosis	492	1,111	1,270	1,401	1,871	2,914	5,614	9,537

Deaths from tuberculous diseases in Boston for the year 1900.

[Population, 560,892.]

Form of disease.	Under 1 year.	Under 15 years.	Under 25 years.	All ages.
Tabes mesenterica	2	10	12	18
Tubercular meningitis	43	117	123	131
Other forms of tuberculosis, scrofula	20	51	79	181
Total other than phthisis	65	178	214	330
Phthisis	11	52	318	1,247
Total tuberculosis	76	230	532	1,577

Deaths from tuberculous diseases in Chicago for the years 1897 and 1898.

[Population, 1897, 1,619,226; 1898, 1,650,000.]

Form of disease.	Under 1 year.	Under 5 years.	Under 10 years.	Under 20 years.	Under 30 years.	All ages.
Tuberculosis mesenteric (1897) and peritoneal (1898)	3	12	16	29	33	56
Tuberculosis, cerebral	75	190	225	249	270	293
Tuberculosis, other organs	40	88	110	158	248	460
Total other than phthisis	118	290	351	436	554	809
Phthisis	66	196	250	700	2,061	4,596
Total tuberculosis	184	486	601	1,136	2,615	5,405

It is evident from these tables that abdominal tuberculosis is a very common disease in England, Wales, and Scotland, and that it is by no means unknown in the cities of Berlin, Paris, New York, Boston, and Chicago.

To show more clearly the numerical relation of the different forms of tuberculosis, a series of tables of percentages have been compiled, corresponding with those just given, showing the number of deaths.

Deaths from tuberculosis in England and Wales for the year 1898.

[Percentage of each form.]

Form of disease.	Under 1 year.	Under 5 years.	Under 10 years.	Under 15 years.	Under 20 years.	Under 25 years.	Under 35 years.	All ages.
Tabes mesenterica	46.23	36.00	32.90	30.48	25.61	21.08	15.74	10.57
Tubercular meningitis (acute hydrocephalus)	28.11	34.95	35.48	33.72	28.36	23.25	17.10	11.11
Other forms of tuberculosis, scrofula	18.68	18.42	18.59	18.65	17.23	15.26	12.51	9.59
Phthisis	6.98	10.63	13.03	17.15	28.80	40.41	51.65	68.73
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Deaths from tuberculosis in Scotland for the year 1898.

[Percentage of each form.]

Form of disease.	Under 1 year.	Under 15 years.	Under 25 years.	All ages.
Tabes mesenterica	80.33	24.79	16.10	9.34
Tubercular meningitis.....	44.42	38.13	23.33	12.70
Other forms of tuberculosis, scrofula	15.36	14.44	11.17	8.04
Phthisis.....	9.89	22.64	49.40	69.92
Total.....	100.00	100.00	100.00	100.00

Deaths from tuberculosis in London for the year 1898.

[Percentage of each form.]

Form of disease.	Under 1 year.	Under 15 years.	Under 25 years.	All ages.
Tabes mesenterica	43.56	27.62	20.89	9.03
Tubercular meningitis.....	28.72	36.01	27.26	11.32
Other forms of tuberculosis, scrofula	20.63	21.20	17.77	8.90
Phthisis.....	7.09	15.17	34.08	70.75
Total.....	100.00	100.00	100.00	100.00

Deaths from tuberculosis in Berlin for the year 1898.

[Percentage of each form.]

Form of disease.	Under 1 year.	Under 15 years.	Under 25 years.	All ages.
Tabes mesenterica	2.84	4.57	2.73	1.80
Tubercular meningitis.....	27.66	32.33	16.86	6.00
Other forms of tuberculosis, scrofula	14.18	6.31	3.67	2.23
Phthisis.....	56.32	56.79	76.74	89.97
Total.....	100.00	100.00	100.00	100.00

Deaths from tuberculosis in Paris for the year 1897.

[Percentage of each form.]

Form of disease.	Under 1 year.	Under 15 years.	Under 25 years.	All ages.
Tabes mesenterica	1.65	3.06	1.87	1.33
Tubercular meningitis.....	57.85	54.49	27.42	8.60
Other forms of tuberculosis, scrofula	20.66	12.76	10.63	10.06
Phthisis.....	19.84	29.69	60.08	80.02
Total.....	100.00	100.00	100.00	100.00

Deaths from tuberculosis in New York for the year 1899.

[Percentage of each form.]

Form of disease.	Under 1 year.	Under 15 years.	Under 25 years.	All ages.
Tabes mesenterica	6.91	2.86	1.37	0.47
Tubercular meningitis	57.11	54.68	27.28	9.06
Other forms of tuberculosis, scrofula	16.06	16.62	11.25	6.43
Phthisis	19.92	25.84	60.10	84.04
Total	100.00	100.00	100.00	100.00

Deaths from tuberculosis in Boston for the year 1900.

[Percentage of each form.]

Form of disease.	Under 1 year.	Under 15 years.	Under 25 years.	All ages.
Tabes mesenterica	2.63	4.85	2.26	1.14
Tubercular meningitis	56.58	50.87	23.12	8.31
Other forms of tuberculosis, scrofula	26.32	22.17	14.85	11.48
Phthisis	14.47	22.61	59.77	79.07
Total	100.00	100.00	100.00	100.00

Deaths from tuberculosis in Chicago for the years 1897 and 1898.

[Percentage of each form.]

Form of disease.	Under 1 year.	Under 5 years.	Under 10 years.	Under 20 years.	Under 30 years.	All ages.
Tuberculosis, mesenteric (1897) and peritoneal (1898)	1.63	2.47	2.66	2.55	1.38	1.04
Tuberculosis, cerebral	40.76	39.09	37.44	21.92	10.33	5.42
Tuberculosis, other organs	21.74	18.11	18.30	13.91	9.48	8.51
Phthisis	35.87	40.33	41.60	61.62	78.81	85.03
Total	100.00	100.00	100.00	100.00	100.00	100.00

NOTE.—In these tables the term "tabes mesenterica" is believed to cover tuberculosis of the intestines, peritoneum, and abdominal lymphatic glands.

Taking England and Wales, it is seen that in children under 1 year old tabes mesenterica constitutes 46.23 per cent of the total cases of tuberculosis at that age, while phthisis constitutes but 6.98 per cent. Under 5 years the figures are 36 per cent for tabes mesenterica and 10.63 per cent for phthisis. It is not until the age of 20 years is reached that the percentage of phthisis exceeds that of tabes mesenterica. In Berlin, Paris, New York, Boston, and Chicago the statistics, however, are quite different, and the number of cases of abdominal tuberculosis returned is very much smaller.

Your committee has added a table compiled from these statistics showing the deaths per million population from the different forms of tuberculosis in England, Wales, and Scotland, and in the cities mentioned. From this table (p. 26) the extreme frequency of intestinal tuberculosis in England and Scotland is made manifest.

Deaths per million population from different forms of tuberculosis.

Form of disease.	England and Wales, 1898.	Scotland, 1898.	London, 1898.	Berlin, 1898.	Paris, 1897.	New York, 1899.	Boston, 1900.	Chicago, 1897-98.
<i>Under 1 year.</i>								
Tabes mesenterica	104	56	134	2	2	10	4	1
Tubercular meningitis	63	82	88	22	56	79	77	23
Other forms of tuberculosis, scrofula	42	29	63	11	20	22	35	12
Phthisis	16	18	22	44	19	28	20	20
Total tuberculosis	225	185	307	79	97	139	136	56
<i>Under 15 years.</i>								
Tabes mesenterica	177	185	200	16	19	11	18	9
Tubercular meningitis	196	285	261	116	333	216	209	76
Other forms of tuberculosis, scrofula	108	108	154	23	78	66	91	48
Phthisis	100	169	110	203	182	102	93	214
Total tuberculosis	581	747	725	358	612	395	411	347
<i>Under 25 years.</i>								
Tabes mesenterica	186	205	206	20	24	11	21	11
Tubercular meningitis	205	297	269	122	355	224	219	83
Other forms of tuberculosis, scrofula	135	142	176	26	138	92	141	76
Phthisis	357	629	337	556	778	493	567	630
Total tuberculosis	883	1,274	988	724	1,295	820	948	800
<i>All ages.</i>								
Tabes mesenterica	202	223	221	40	61	13	32	17
Tubercular meningitis	213	303	278	134	398	243	234	90
Other forms of tuberculosis, scrofula	184	192	218	50	465	173	322	141
Phthisis	1,317	1,668	1,734	2,009	3,702	2,258	2,223	1,406
Total tuberculosis	1,916	2,386	2,451	2,233	4,626	2,687	2,811	1,654

The one point which it is desired to impress at this time is that abdominal tuberculosis is not so rare that it can properly be ignored and that the statistics of some countries show a remarkable number of cases.

POSTMORTEM EXAMINATIONS SHOWING INTESTINAL TUBERCULOSIS.

The fourth line of evidence bearing upon this question is obtained from postmortem examinations.

Koch says that among many cases of tuberculosis examined after death he remembered having seen primary tuberculosis of the intestine only twice. Among the great postmortem material of the Charité Hospital, in Berlin, 10 cases of primary tuberculosis of the intestine occurred in 5 years. Among 933 cases of tuberculosis in children at the Emperor and Empress Frederick's Hospital for Children, Baginsky never found tuberculosis of the intestines without simultaneous disease of the lungs and the bronchial glands. Among 3,104 postmortems of tubercular children, Biedert observed only 16 cases of primary tuberculosis of the intestine.

Are these selected statistics, or are the results of postmortems in Germany so different from what they are in England?

In 269 autopsies of tuberculous children, Still²⁰ determined the channel of infection with some degree of certainty in 216 cases, and in 63 of these primary infection was probably through the intestine. Carr,²¹ in a series of 120 autopsies on tuberculous children at the Chelsea Children's Hospital, found that 16.7 per cent showed evidence of primary abdominal infection. Guthrie,²² at the Paddington Green Children's Hospital, in a series of 77 cases, found evidence of primary intestinal infection in 19 cases. Shennon²³ collected 355 cases of tuberculosis from the postmortems at the Royal Hospital for Sick Children, Edinburgh, in 331 of which he was able to determine the channel of infection. In 28.1 per cent of these cases it was alimentary. Bollinger, in his address at the International Tuberculosis Congress at Berlin in 1899, quoted with approval the autopsies by Heller (Kiel) of 248 tuberculous children, which showed, in 45.5 per cent of the cases, tuberculosis of the mesenteric glands. From these it was concluded that milk played a leading role in the so-called transmitted tuberculosis of children.

Northrup²⁴ refers to 125 postmortems at the New York Foundling Asylum on tuberculous children, in 34 of which the bronchial nodes were large and cheesy, likewise the mesenteric nodes; the lungs contained tubercles, as did the liver, spleen, kidneys, and meninges. The primary seat of infection in these was not clear. In the remaining 91, 3 were primarily of mesenteric lymph node infection, and 88 were primarily of bronchial node infection.

G. Sims Woodhead,²⁵ in 1894, writing on channels of infection in tuberculosis, said:

I have seen in case after case in children and in animals fed on tuberculous material, the lungs markedly affected, but in a large proportion of these cases it has been possible to trace the course of invasion back from an old caseous or calcareous mesenteric gland, through the chain of retroperitoneal glands, up through the diaphragm to the posterior mediastinal and bronchial glands, and so on to the lung. I have not seen this in a few cases only, but in dozens of children, in a few adults, and in many animals.

Sheridan Delépine,²⁶ Proctor professor of pathology, Owens College, in a lecture on tuberculosis and the milk supply, said:

A very striking proof of the frequency of infection through the intestine fell under my notice 6 years ago. Dr. Simcock was investigating in my laboratory the pathology of chronic wasting of children due to improper feeding. He selected 13 cases out of many more in which there was no evidence of tuberculosis in the parents or in the various organs of the children as examined in the postmortem room. He considered these cases free from tuberculosis. I was not, however, quite convinced. We carefully examined the mesenteric glands of all these children with the object of discovering whether some might not be tuberculous. In 2 of these cases the mesenteric glands showed clear tuberculous lesions under the microscope, and in 5 more the mesenteric glands presented lesions suggesting the possibility of incipient tuberculosis. The presence of 2 clear cases of tuberculosis among 13 cases carefully selected as free from tuberculosis is specially significant.

These quotations are sufficient to make it clear that primary intestinal infection is much more frequent than is indicated by Koch's paper. After expressing himself "that a case of tuberculosis has been caused by alimenta can be assumed with certainty only when the intestine suffers first—i. e., when so-called primary tuberculosis of the intestine is found"—he first endeavors to show that such cases are extremely rare, and then proceeds to contradict his first assertion that it can be assumed with certainty to have been caused by alimenta, by saying "it is by no means certain that such cases are due to infection by bovine tuberculosis, it being just as likely that they were caused by the widely propagated bacilli of human tuberculosis which may have got into the digestive canal by some way or other, for instance, by swallowing saliva of the mouth."

It is clear that dust and bacilli inhaled with the air are deposited upon the mucous membrane of the nose, pharynx, and trachea, and that such inhaled particles must be swallowed unconsciously, as pointed out by Lord Lister in his letter to the British Medical Journal (August 3, 1901); also that persons infected with pulmonary tuberculosis swallowed enormous numbers of bacilli. Still it is known from postmortem examinations that pulmonary tuberculosis is more common than intestinal, and that a considerable proportion (placed by Lord Lister at one-third) of the people who die of pulmonary tuberculosis escape intestinal infection, although they are proved susceptible and have passed into their stomachs great quantities of bacilli daily for months or years. What is the explanation of this? With even the inhaled bacilli more likely to follow the digestive than the respiratory tract, why is not intestinal tuberculosis much more common than the pulmonary form?

Writers have attempted to explain this by supposing that the intestine is an unfavorable position for the bacilli to gain entrance to the tissues. Judging by the ease with which animals are infected by bovine bacilli through the digestive tract, this explanation is hardly tenable. It would appear rather that the true cause of the phenomenon is the lack of pathogenic power in the human bacillus, which has been shown experimentally on animals, and that this lack of virulence makes it difficult for human bacilli to withstand the gastric juice and other unfavorable conditions and have sufficient activity remaining to infect the body after reaching the intestine. On the other hand, the more virulent bovine germ would be more likely to maintain its activity and would be more apt to produce infection with a smaller number of germs.

The fact is that in some countries intestinal tuberculosis is comparatively rare, even with children. The statistics of Berlin, Paris, New York, Boston, and Chicago prove this, although pulmonary tuberculosis is very prevalent. Surely the air and the habitations of these

places must contain a maximum number of bacilli from the human disease. If intestinal tuberculosis is caused by such human bacilli, either inhaled or taken into the mouth in other ways, why is there not as much intestinal tuberculosis in those cities as in England and Scotland? Are British babies the only ones that swallow the inhaled bacilli? How can we explain the occurrence of 134 cases of *tabes mesenterica* per million inhabitants in children under 1 year in London as against only 2 cases in Paris, when there are more than twice as many cases of pulmonary tuberculosis per million inhabitants in Paris as in London? We see here, as in the statistics brought forward by Thorne, that there is no relation between intestinal tuberculosis and pulmonary tuberculosis; in other words, that infection by human bacilli apparently plays a very subordinate part in the causation of tuberculosis of the abdominal organs. This conclusion we think is legitimate and clearly follows from the statistics presented.

Why is *tabes mesenterica* so prevalent in Great Britain? It is a question which can properly be answered only by careful inquiry in that country. Tuberculosis is very common among the cattle there, but possibly not more so than on the continent. More attention appears, however, to be given to the inspection of meat in Berlin and Paris than in London, and possibly the same may be true of milk. Meat is more frequently eaten underdone in London, and milk is probably less frequently sterilized. In the United States we have far less tuberculosis among cattle, and also an efficient Federal meat inspection. Our milch cows do not show more than one-tenth and our beef cattle not more than one hundredth of the tuberculosis which is found in Great Britain.

Before closing this discussion your committee desires to call attention to the fact that infection of the lungs is not always the result of inhaled bacilli. There is apparently as much opportunity for bacilli taken with the food to infect the pharyngeal, tracheal, bronchial, and mediastinal glands and the lungs as there is for inhaled bacilli to infect the intestine. When all cases of pulmonary tuberculosis are cited as necessarily due to inhaled bacilli and as not by any possibility due to infection with the food, an error is committed.

G. Sims Woodhead²⁰ several years ago pointed out how frequently bacilli gained entrance through the lymphoid tissue of the tonsil, and St. Clair Thomson has recently expressed the opinion that all germs are deposited before the air reaches the larynx and that infection most probably occurs through the lymphoid tissue of the naso-pharynx and pharynx. He says: "There appears to be no justification for the generally accepted idea that the bacillus is inhaled directly into the pulmonary alveoli."

He also says of infection through the pharynx:

In many of these cases the process can be traced from the glands in the tonsil down into the neck and so on to the thorax by the mediastinal and post-sternal glands and by the intercostal lymphatics and glands, and it is interesting in such cases to note how the lungs may be perfectly healthy until the glands at their root or in the pleura have become distinctly affected.

Again he²⁵ says:

We have also an example of secondary affection of the lungs following tubercle of the pharyngeal tonsillar structures, through the glands in the neck, then those in the thorax, and finally to the lung itself, in the examples that have already been given in the infection of the pig by tuberculous milk, etc. Moreover, I have seen a similar line of invasion in children.

Koch tells us that in an experiment in which sputum was fed to 6 pigs there was no trace of tuberculosis found postmortem "except here and there little nodules in the lymphatic glands of the neck, and in one case a few gray nodules in the lungs." It appears, then, that he did get some infection in the pigs by feeding human sputum, and that the lesions, far from being in the intestines, were in the neck and lungs.

Referring to the pigs which had eaten bacilli of bovine tuberculosis, Koch says they "had, without exception, severe tubercular diseases, especially tubercular infiltration of the greatly enlarged lymphatic glands of the neck and of the mesenteric glands, and, also, extensive tuberculosis of the lungs and spleen." There is nothing said about primary tuberculous lesions of the intestines, and we are forced to the conclusion that his own postmortem notes do not sustain his contention that such lesions are essential in cases of infection through contaminated food. Lord Lister²⁷ is said to have pointed out in his reply to Koch that if primary intestinal tuberculosis were rare in children, mesenteric tuberculosis was common, and said that the interpretation seemed to him to be that the bacilli passed through the intestinal mucous membrane without causing any obvious lesion and were arrested in the glands. This interpretation seems to be accepted by most pathologists, and is certainly in harmony with the results of feeding experiments with animals. Most forms of primary abdominal tuberculosis, whether affecting the intestines, peritoneum, lymphatic glands, spleen, or liver, are, therefore, in all probability due to infection through the intestine. More than this, many cases of neck and lung infection are due to bacilli taken with the food. Ravenel²⁸ has recently said:

Dr. Pearson and I have held for a long time that food tuberculosis may appear first in the lungs or cervical glands. I have just received a letter from Dr. Pearson saying that he has killed two cows fed on tuberculosis matter, and "both had extensively tubercular lungs, and lesions nowhere else. The postpharyngeal lymph glands were normal. Neither had the slightest disease along the digestive tract." We have made similar observations repeatedly on dogs and pigs.

Observations of the same kind have been frequently made in the experiments of the Bureau of Animal Industry.

If, therefore, it is true and may be admitted that some cases of intestinal tuberculosis are caused by bacilli inhaled or which reach the saliva from the affected lung, it is also true that in even a larger number of cases the respiratory organs are infected by bacilli taken with the food. Certainly this is the case with animals, as shown by feeding experiments, and probably also with the human subject. The location of the lesions is therefore a very uncertain guide in many cases as to the channel by which the infection entered the body.

The new method of diagnosis which Koch desires us to accept—namely, the culture of the bacillus and the subcutaneous inoculation of cattle with the cultures—is yet of doubtful reliability. It has been assumed by Smith and Koch that the bacilli of bovine tuberculosis, if they produce disease in man, would retain their peculiar characteristics indefinitely, so that when isolated from the human lesions and inoculated in cattle they could be identified by their virulence for bovine animals. This is an assumption which has never been demonstrated. The method may or may not be correct, and it is only reasonable for us to decline to accept it for deciding so important a question until after its efficiency and reliability have been demonstrated. Koch says: "Hitherto nobody could decide with certainty in such a case whether the tuberculosis of the intestine was of human or of animal origin. Now we can diagnose them." It is only just to our own countryman to say that we could make the diagnosis as well after the publication of Theobald Smith's paper three years ago as we can after reading Koch's address. But the method is still in its infancy, and no one has cultivated germs known to be of bovine origin that have existed for some time in the human subject to determine whether or not they retain their distinctive properties. Bacilli from different cases of human tuberculosis differ in virulence, and the extremes of pathogenic power in such bacilli have never yet been established.^a It is also true that bacilli from bovine sources differ in virulence, and here again the extremes of virulence have never been determined. Moreover, we do not know how much or how soon the bovine bacillus is modified when it propagates itself in human tissues. The experiments of Smith

^aLartigau²⁹ has recently reported the results of interesting investigations on the range of variation of the virulence of tubercle bacilli from various classes of lesions in human beings. He concludes that tubercle bacilli of widely different virulence may exist in different cases of human tuberculosis. One specimen which he encountered presented distinctive features worthy of note. "Its growth was of very slow development, the colonies few in number, and not unlike ground glass, an appearance to which Theobald Smith has referred in connection with tubercle bacilli of bovine origin. When the extreme virulence of this tubercle bacillus for guinea pigs and rabbits is associated with the morphological and cultural peculiarities just noted, the whole closely suggests the bacillus tuberculosis of bovine derivation as described by Smith."

have opened up a wide field and lead to important suggestions but we can not yet say what conclusions will be reached by experimenting along the suggested lines.

It is to be observed that Koch does not positively answer the question as to the susceptibility of man to bovine tuberculosis, but acknowledges that it "will not admit of absolute decision to-day or to-morrow." He insists that "if such susceptibility really exists, the infection of human beings is but a very rare occurrence," and estimates "the extent of the infection by the milk and flesh of tuberculous cattle, and the butter made of their milk as hardly greater than that of hereditary transmission." This language shows his uncertainty on the great question which he has raised and bearing upon which he has offered so little evidence. If the extent of the infection from bovine sources equals that by hereditary transmission, then the danger exists, it is a real danger, and we should strive to ascertain its exact extent and how much greater it may become.^a

To ask the medical profession at this time to adopt sweeping generalizations on inconclusive experiments and on mere hypotheses is absurd. To expect that the definite and positive evidence from accidental inoculations, clinical observations, vital statistics, and post-mortem records will be discarded in order to adopt such hasty generalizations is ridiculous. More positive evidence will doubtless be forthcoming in the near future, as investigators will not rest until the most exhaustive researches have been made. In the end even this dramatic promulgation of a dangerous doctrine, practically unsupported by facts, will bring good to the cause of sanitation. What we must guard against is the influence of the sensationalists and of those very impressionable persons who are ever ready to accept a new doctrine which comes with the sanction of authority, no matter upon how slight a foundation of fact it rests.

In this case it is reassuring to find that the British Congress on Tuberculosis not only did not accept the doctrine, but declared that "medical officers of health should continue to use all the powers at their disposal, and relax no effort to prevent the spread of tuberculosis by milk and meat." In this conclusion your committee most emphatically concurs.

^aIf it were true that man is entirely insusceptible to bovine tuberculosis, it would appear that monkeys, the animals most closely related to man, should also be insusceptible or at least should not be easily infected with bovine bacilli. An experiment of the Bureau of Animal Industry, concluded shortly after this report was presented, indicates, on the contrary, that these animals are extremely susceptible to this form of tuberculosis. A baboon inoculated subcutaneously showed an ulcer locally, great enlargement of the axillary glands, and later, symptoms of acute generalized tuberculosis. After death the lungs, liver, and spleen in particular were found filled with tubercles and other organs were more or less involved. Another monkey of a different species, inoculated at the same time, has become greatly emaciated and has probably also contracted the disease.³⁰

BOVINE TUBERCULOSIS AFFECTING THE PUBLIC HEALTH. (Second report.)^a

By D. E. SALMON, D. V. M.,

Chief of the Bureau of Animal Industry and Chairman of the Committee on Animal Diseases and Animal Food of the American Public Health Association.

Your committee on animal diseases and animal food respectfully report as follows with reference to subjects which have received their attention during the time that has elapsed since the last meeting of the association:

The last report which this committee had the honor to submit discussed the important question of the relation of bovine tuberculosis to the public health, reviewed the data available at that time, and concluded that the weight of evidence was overwhelmingly against the assertion of Koch that cattle are insusceptible to human tuberculosis and that man is insusceptible to bovine tuberculosis. As anticipated in that report, numerous investigators at once instituted researches, and the results of the experiments are now being made public. Your committee feel that the question is of such general interest, and, indeed, that its elucidation is so essential to the proper performance of the duty of the sanitarian, that they venture to review it again in the light of the most recent information attainable. There are some apparent inaccuracies in the paper which Koch² read before the British Congress on Tuberculosis, to which your attention is invited. He says:

Even in my first circumstantial publication on the etiology of tuberculosis I expressed myself regarding the identity of human tuberculosis and bovine tuberculosis with reserve.

A reference to the paper which Koch mentions will show that he expressed himself as follows:³¹

It is not the peculiar structure of the tubercle, not its lack of blood vessels, not the presence of giant cells, that will give the solution, but rather the proof of the tuberculosis bacilli, whether it be in the tissue by means of staining reaction or whether it be by means of culture upon coagulated blood serum. This criterion being adopted as a foundation principle, according to my investigations, miliary tuberculosis, caseous pneumonia, caseous bronchitis, intestinal and glandular tuberculosis, bovine tuberculosis, spontaneous and inoculation tuberculosis of animals must be declared as identical.

^aReport of committee on animal diseases and animal food to American Public Health Association at New Orleans, La., December 8-12, 1902. Published also in Nineteenth Annual Report of Bureau of Animal Industry.

Again he³¹ says:

The tuberculosis of domesticated animals, especially bovine tuberculosis, undoubtedly forms another source of infection with tuberculosis. By this is also characterized the position which the care of health is to occupy in the future in consideration of the harmfulness of the meat and of the milk of animals suffering with bovine tuberculosis. Bovine tuberculosis is identical with human tuberculosis, and therefore a disease transmissible to man. It is therefore to be treated just like other infectious diseases transmissible from animals to human beings. However great or small may be the danger which results from the consumption of meat or milk affected with bovine tuberculosis, it is present, and must therefore be avoided. It is sufficiently well known that meat affected with anthrax is eaten by many persons and often for long periods of time without harm, and yet no one will draw the conclusion from this that the traffic in such meat is to be permitted.

It is hardly necessary to add that the question appears to have been treated, in the paper mentioned, without any reservations whatever, and that the statements of the identity of human and bovine tuberculosis were emphatic and unequivocal. Of course, it is allowable for an author to change his views with the discovery of additional facts, but he may not cite his earlier paper in support of the later contention when the language of the earlier paper gives, as in this case, an opposite impression.

Again, with reference to the results of the earlier investigators of the subject, he² states:

If one studies the older literature of the subject, and collates the reports of the numerous experiments that were made in former times by Chauveau, Guenther and Harms, Bollinger, and others, who fed calves, swine, and goats with tubercular material, one finds that the animals that were fed with the milk and pieces of the lungs of the tubercular cattle always fell ill of tuberculosis, whereas those that received human material with their food did not.

In your committee's last report³³ quotations were made from Chauveau's³ paper showing clearly that in his experiments cattle were successfully infected with human tuberculous material by ingestion, by intravenous injection, and by subcutaneous inoculation. From all of these experiments he concluded that the human tubercular virus acts on the bovine species exactly like the tubercular virus which comes from the bovine species itself.

Bollinger³³ in 1879 and Sidney Martin³⁴ in 1895 also obtained successful results with bovine animals, one by inoculation into the peritoneal cavity, the other by feeding sputum. Your committee have not been able to consult the papers of Guenther and Harms, which were also cited by Koch, but whatever their results may have been it is sufficiently demonstrated that the older investigators were not unanimous in finding that "the animals that were fed with the milk and pieces of the lungs of tubercular cattle always fell ill of tuberculosis, whereas those that received human material with their food did not." What is most striking in a review of these earlier investigations is the variability of the results. Chauveau found human as virulent as

bovine material for bovine animals. Martin found human sputum much less virulent than bovine material, while others failed entirely in the effort to infect bovine animals with human tuberculous material.

It would seem that the cause of this lack of harmony in the results of experiments of the same character should have been suggested by the researches of Vagedes,³⁵ who, in 1896, studying 28 human cultures, discovered 1 of these which was much more virulent than the others, and which was more virulent than either of 2 bovine cultures used in the investigation.

Theobald Smith³⁶ says in regard to this work:

It is somewhat remarkable that this exceptional culture of Vagedes, described in a work done under the direction of Koch himself, was wholly ignored by the latter.

Lartigau³⁹ in 1901 published results from which he concluded that tubercle bacilli of widely different virulence may exist in different cases of human tuberculosis. One culture obtained by him was extremely virulent for guinea pigs and rabbits, and had morphological and cultural peculiarities which closely suggested the bacillus tuberculosis of bovine derivation as described by Smith.

Koch² says of his experiments:

In some cases the tubercle bacilli or the sputum were injected under the skin, in others into the peritoneal cavity, in still others into the jugular vein. Six animals were fed with tubercular sputum almost daily for 7 or 8 months; 4 repeatedly inhaled great quantities of bacilli, which were distributed in water and scattered with it in the form of spray. None of these cattle (there were 19 of them) showed any symptoms of disease, and they gained considerably in weight.

For the discrimination between human and bovine bacilli he recommends the subcutaneous inoculation of bovine animals. Investigators who have since endeavored to elucidate the subject have therefore endeavored to infect animals with human material by any one or more of these methods which failed in the hands of Koch and his assistants. It is very interesting to study their results.

RECENT RESEARCHES WITH REFERENCE TO THE COMMUNICABILITY OF HUMAN TUBERCULOSIS TO ANIMALS.

Ravenel,³⁷ of the Pennsylvania Live Stock Sanitary Board, and a member of this committee, in 1898 fed 4 calves with human sputum. Postmortem examination proved that all had become affected with tuberculosis, the lesions in 2 being quite extensive. In March, 1901, he obtained material from the mesenteric glands of a child which died of tubercular meningitis. The bacilli from this material have proved very virulent for bovine animals. One calf inoculated intravenously with a suspension of a culture of this bacillus showed marked illness during life and died in 17 days. Both lungs were found thickly studded throughout with miliary nodules. The bronchial and mediastinal

glands were much enlarged and soft, the former showing small areas of caseation. The liver was soft and friable, and several nodules were visible on its surface.

A second calf was inoculated into the peritoneal cavity with a similar suspension of a culture of this bacillus. This animal died in 27 days, after showing an abnormally high temperature from the eighth day. It was greatly emaciated, having lost 37 pounds in weight. The central and posterior portions of the lungs showed many areas deep in color and solid to the feel. These were thickly studded throughout with minute grayish nodules. The suprasternal lymph glands were as large as goose eggs, and contained cheesy areas. The mediastinal glands were much enlarged. The peritoneum was everywhere enormously thickened and practically converted into a tuberculous mass. The omentum and liver contained many nodules.

A cow was inoculated intravenously with only 2.5 c. c. of a suspension of a similar culture and died in 17 days. The lungs were thickly studded throughout with miliary nodules.

A second culture obtained from the mesenteric glands of a child, and which in its manner of growing and microscopical appearance led the investigator to consider it a typical human culture, was found to be unexpectedly virulent when tested upon dogs. A calf inoculated intravenously with suspension of a culture was killed on the forty-sixth day, death then appearing imminent. The anterior lobes of both lungs were thickly studded with minute nodules averaging 1 mm. in diameter. The bronchial and mediastinal glands were enlarged, and scrapings from the cut surfaces showed an enormous number of tubercle bacilli. Many yellow nodules were seen in the mediastinal glands. In the liver were many minute nodules, sections of which showed large numbers of tubercle bacilli. The spleen showed round-cell infiltration, giant cells, and many tubercle bacilli. There were also white areas in the kidneys with round-cell infiltration and many bacilli.

In the Bureau of Animal Industry a number of virulent cultures of tubercle bacilli have been obtained from human sources. A few of these are worthy of notice in this connection. De Schweinitz,³⁰ of the Biochemic Division of the Bureau of Animal Industry, isolated a tubercle bacillus from a mesenteric gland of a child affected with tubercular peritonitis. This bacillus, when grown on egg medium, corresponded to the bovine type. A calf received intravenously 5.5 c. c. of a suspension made from an egg culture. This animal died in 20 days of generalized tuberculosis. The lungs were a mass of small tubercles, while the bacilli were demonstrated in the liver, spleen, kidneys, and mesenteric and mediastinal glands. The same investigator obtained a culture from another child affected with peritoneal tuberculosis. This culture also corresponded to the bovine type

when grown on egg medium. A calf inoculated intravenously with 5 c. c. of a suspension of egg culture died in 17 days. The autopsy showed generalized tuberculosis, numerous bacilli being demonstrated in the lung, liver, spleen, and mediastinal glands. A steer was inoculated subcutaneously with a piece of tuberculous tissue from this child. The animal was killed at the end of 6 months, and the autopsy showed the flank and shoulder glands enlarged, caseous, and calcified. There were numerous excrescences upon the border of the lung and upon the pleural surface of the diaphragm. Bacilli were demonstrated in these excrescences and also in the glands. Both of these cultures are therefore very virulent for bovine animals when given by intravenous inoculation, and one at least is virulent when injected subcutaneously.

A calf previously tested with tuberculin, as was done with all the larger animals used in these experiments, was inoculated subcutaneously in the side of the neck with 5 c. c. of a suspension of a culture of this bacillus. This animal presented the ordinary signs of tubercular infection, and, being emaciated, weak, unable to rise, and in a dying condition, was killed on the thirty-first day. The autopsy showed generalized tuberculosis. The prescapular gland and mediastinal glands were enlarged and tubercular, the lungs were filled with tubercular nodules, and the liver was affected to an almost equal extent. The omentum showed many tubercular nodules and the kidneys a small number.

Mohler,³⁸ of the Pathological Division of the Bureau of Animal Industry, has obtained three cultures of bacilli from human sources which, because of their virulence for the species of animals on which they have been tested, are also worthy of mention. One of these, which had its source in the mesenteric gland of a girl who died of tuberculosis, appears more virulent for goats and cats than the first culture of Ravenel above mentioned. A goat inoculated subcutaneously was in poor condition and growing thinner at the end of 137 days. A cat inoculated in the same manner died in 104 days of pulmonary tuberculosis. A rabbit was in poor condition at the end of 137 days. The bacilli cultivated in dog serum averaged $2\ \mu$ in length, some slightly curved and beaded. This bacillus was of the human type, but when recovered from the cat it was markedly reduced in length and slower in growth.

Another bacillus obtained from the mesenteric gland of a boy affected with tuberculosis is shorter, averaging from 1.2 to $1.5\ \mu$, is beaded, and grows rapidly and luxuriantly. A goat inoculated subcutaneously with this culture died in 37 days with miliary tuberculosis of the lungs, involving the axillary and prescapular glands. A dog inoculated in the same manner after 59 days was thin and becoming emaciated, and had an ulcer at the point of inoculation. A cat similarly inoculated was in poor condition at the end of 59 days. The

third germ, obtained by Mohler, is particularly worthy of attention, because it was isolated from human sputum. It is, when grown on dog serum, 1.7 to 2.2 μ in length, slender, beaded, and curved. A goat inoculated subcutaneously died in 95 days of pulmonary tuberculosis. There were also tubercular lesions at the point of inoculation and in the prescapular gland. A cat inoculated subcutaneously died in 23 days of generalized tuberculosis. A rabbit inoculated in the same manner died in 59 days of pulmonary tuberculosis. A bovine culture was used for comparison with the cultures just described and killed a goat in 55 days, as compared with 37 days for the second human culture and 95 days for the third human culture. The bovine germ also killed a rabbit in 69 days as compared with 59 days for the third human culture. This work also shows that it is not a difficult matter to obtain very virulent tubercle bacilli from human sources, and that some of these are just as virulent as bovine bacilli.

At the British Congress on Tuberculosis, Thomassen³⁹ reported an experiment in which a calf was inoculated in the anterior chamber of the eye with a pure culture of a tubercle bacillus isolated from a case of tuberculous arthritis in man. When killed after 6 weeks, it was found that both lungs contained numerous miliary tubercles and some gray fibrous tubercles of larger size. The path of infection from the eye to the lung could be traced by the condition of the sub-parotideal, cervical, mediastinal, and bronchial lymph glands of the same side.

De Jong⁴⁰ reports, as a result of a series of inoculations, that 7 bovine animals, namely, 2 calves 6 months old, 3 steers 2 years old, 1 18 months, and 1 calf 7 or 8 months old, all became tuberculous by the injection of tubercle bacilli of human origin. Consequently all the bovine animals used in the experiment were infected by human bacilli. The disease produced was serious and very extended in only 1 animal, with 4 others it had a retrogressive tendency, and in the 2 remaining cases it was progressive. He concludes that these results demonstrated that bacilli isolated from the human body or from sputum are capable of causing tuberculosis of cattle.

Delépine⁴¹ recently stated, in a discussion on the relationship of human and bovine tuberculosis, that he had been able to obtain from the human subject bacilli just as virulent as the bovine tubercle bacillus, but in most the human tubercle bacillus was less virulent.

Orth⁴² made experiments with 3 calves, 3 hogs, and 3 goats. The infectious material was obtained from a case of phthisis cavernosus by inoculating a guinea pig and then obtaining cultures from this animal from brain and other media. In the experiments bouillon cultures of the organism were used, and in some cases tuberculous organs from rabbits. One calf inoculated into the lung through the trachea gave an entirely negative result. The second, inoculated between the

abdominal muscles, showed only a local caseous abscess. The third, which was inoculated in the peritoneal cavity with two pieces of tuberculous kidney from a rabbit, died on the twenty-sixth day of a general tuberculous peritonitis. The serous membranes were covered with miliary and submiliary tubercles. The great omentum had nodules scattered throughout and small nodules were visible on the serous membrane of the intestine. The mesenteric portal and retrosternal lymph glands were much enlarged and showed gray and white nodules upon section. There was no doubt but that a progressive fatal tuberculosis was produced in this calf by material originating in the human subject.

Of the 3 pigs, 2, which were inoculated intraperitoneally with the bouillon culture, gave negative results. The third, inoculated through the trachea into the lungs, was killed after 5½ months and a large number of miliary and submiliary tubercles were found in the inferior lobe of the right lung, and there were many yellowish tuberculous nodules in the thymous gland and in the membranes around it. One of the goats inoculated through the trachea into the lung with the bouillon culture showed a number of subcutaneous nodules near the point of inoculation, a large caseous nodule in the thymous gland, and a number of yellowish gray nodules in the inferior lobe of the right and left lungs. The second goat was inoculated intraperitoneally with a small piece of lung from a tuberculous rabbit. The animal was killed after 5 months and a number of nodules were found in the muscles and subcutaneous tissue at the point of inoculation. There were also a number of small, grayish translucent nodules scattered through the omentum, on the diaphragm, and in the neighborhood of the lymph glands; a nodule about the size of a pea was found on the anterior border of the liver. The third goat was inoculated with a piece of tuberculous spleen the size of a pea placed in the peritoneal cavity. On autopsy a number of tubercles were found around the point of inoculation. There was a large group of caseous nodules on the adjoining surface of the stomach and numerous caseous nodules in the omentum, many of these latter having small pedicles. Tubercle bacilli were easily demonstrated, and there was no doubt as to the tuberculous character of the lesions nor that they were produced by human tubercle bacilli.

Stenström⁴³ inoculated 8 calves in various ways with tuberculous sputum rich in tubercle bacilli. Of these, the following showed positive results: No. 224 was inoculated intraperitoneally with 5 c. c. sputum. When killed, after 6 months, the autopsy showed many calcified nodules upon the omentum and an enlargement of the glands connected therewith. Many miliary tubercular foci were present in the liver, and the posterior lobe of the right lung showed hypertrophy of the connective tissue on its serous cover. No. 820 was inoculated in the lungs with 20 c. c. When killed, after 4 months, it showed many tubercular growths on the costal and diaphragmatic pleura, and

tubercular nodules in two mediastinal glands. No. 883 was inoculated intratracheally on October 8 with 6 c. c. and on November 8 with 10 c. c. of sputum; was killed March 17 and showed partially calcified nodules in the posterior and anterior mediastinal glands and also in the bronchial glands. Stenström disagrees with Koch and states that he found it quite easy in his experiments to infect cattle with human tuberculosis.

Fibiger and Jensen⁴⁴ attempted to answer the question as to the intercommunicability of human and bovine tuberculosis by selecting from the various hospitals of Copenhagen those cases of tuberculosis in which the autopsy indicated a primary intestinal infection. They report in all 5 cases of tuberculosis in the following subjects: (1) A 42-year-old woman, (2) an 11-year-old girl, (3) a 6-year-old boy, (4) a 19-months-old girl, and (5) a 4-months-old boy. A 3-months-old calf was inoculated in the thoracic cavity with a suspension made from a mesenteric gland of case No. 1. This calf remained apparently in good condition and was killed at the end of 6 months. Two miliary tubercles and a few fresh pearl nodules were found on the pleura. A 3-months-old calf was inoculated with a suspension made from the spleen of a guinea pig which had been inoculated with a mesenteric gland from case No. 2. When killed, at the end of the fifth month, there were found a large number of small red growths and about twenty small fresh pearl nodules on the omentum. On the diaphragm there were some small nodules and excrescences and one small excrescence on the pulmonary pleura. A calf was inoculated intraperitoneally with a suspension made from the spleen of a guinea pig which had been inoculated from case No. 3. When killed, after about 5 months, the omentum was found filled with tuberculous growths and showed countless small nodules of varying size. There were some small nodules found on other portions of the peritoneum and the surface of the spleen, liver, and diaphragm was covered with small pearl nodules. A calf was inoculated subcutaneously on the right side of the neck with a suspension made from a mesenteric gland of case No. 4. When killed, at the end of the third month, there was a large caseous mass at the point of inoculation; the neighboring glands were large, caseous, and calcified; the lungs had scattered through them many small miliary nodules, and there were a number of excrescences attached to the pulmonary pleura. The bronchial and posterior mediastinal glands were enlarged, hard, and contained fresh, caseous, and calcified nodules. On the surface of the liver there were 10 small pearl nodules. Miliary tubercles were scattered through the liver and spleen, and the omentum was filled with fine, diffused, red new growths.

Two 10-days-old calves were inoculated subcutaneously on the side of the neck with a suspension made from a mesenteric gland from case No. 5. Both of these animals died within 3 weeks from secondary

infection. Nevertheless, there developed a considerable local tuberculosis rich in bacilli. From calf No. 2 a third calf was inoculated subcutaneously on the right side of the neck. A large abscess formed at the point of injection, and the calf, being in a dying condition, was killed at the end of about 2 months. The autopsy showed, in addition to the local lesions, tuberculosis of the adjacent lymph glands, with many new growths on the costal and diaphragmatic pleura and a few on the pulmonary pleura. The lungs contained a countless number of small nodules, in some portions so close together that the air was practically absent. The bronchial and mediastinal glands were enlarged and caseous; the liver, spleen, and kidneys had miliary tubercles scattered through them. The intestinal wall was very rich in fresh nodules and small superficial ulcerations. The mesenteric glands were enlarged and tuberculous. The omentum was rich in small new growths. A cow about 10 years old was inoculated on the left side of the neck with material from calf No. 1 and developed an abscess at the point of inoculation. When killed, at the end of 4 months, in addition to the local abscess, the neighboring glands were enlarged, caseous, and calcified. Miliary tubercles were scattered through the lungs, a nodule the size of a pea was found in the posterior mediastinal gland, and a small number of miliary tubercles in the liver. The authors say that it is thus seen that in the 3 cases of tuberculosis in children the bacilli present were virulent, some of them in the highest degree for calves, and it is probable that the disease in children was caused by bacilli which came from cattle. In the 5 cases there were found bacilli having the greatest variation in virulence for calves, from those which were entirely avirulent to those which were slightly virulent, virulent, and of the highest virulence. They conclude by stating that Koch announced that one could distinguish between human and bovine tuberculosis by inoculating calves subcutaneously. If this is true, then they are of the opinion that 3 of the cases just cited must be considered as "perlsucht," and the idea that tuberculosis of cattle is not virulent for men is disproved.

Max Wolff⁴⁵ reports inoculations from a case of primary tuberculosis of the intestines in man which he considers fully meets all the requirements demanded by Koch for the experimental solution of this uncommonly important question. Two guinea pigs were inoculated with diseased spleen. Seven or 8 weeks afterwards they gave unmistakable evidence of being tuberculous, and were in consequence killed. In each animal both lungs were studded with nodules of the size of a pin head; the liver contained numerous submiliary nodules, and a swollen, cheesy gland was located at the hilus of this organ. The spleen was studded with nodules, many of them exceeding the size of a pin head. A calf was inoculated in the side of the neck with 12 c. c. of sterilized water in which bits of a lung and spleen from

the guinea pig had been macerated. Microscopic examination of this material showed tubercle bacilli to be present in very scanty numbers. Eighty-three days after inoculation the calf was killed. It had become considerably emaciated. The autopsy revealed very severe changes at the point of inoculation and characteristic pearl disease in the internal organs. Upon the surface of the pleura were numerous pedunculated tumors ranging in size from a flaxseed to a cherry, and between these were hyaline miliary tubercles. The lungs showed many grayish tubercles, and the pericardium was covered with them. The mesentery contained countless small tumors, many of them pedunculated. The capsule of the spleen was studded, and the liver showed numerous miliary tubercles in its pulp and on its capsule. Each kidney bore 5 or 6 grayish tubercles the size of flaxseed upon its outer surface. The virulence of the germs isolated from this calf was further proven by inoculations upon the guinea pig. The author thinks that it is here proven that pearl disease of cattle may appear in man.

Nocard⁴⁶ states that cattle are not refractory to human tuberculosis and that it is easy to give the proof of this. If they are inoculated in the arachnoid cavity with a few drops of a feeble culture of the human bacillus they succumb in less than a month, and the autopsy reveals lesions of tuberculous meningitis absolutely identical with those of children. A calf 5 months old inoculated in this way August 2 succumbed August 28. A portion of its pia mater, infiltrated with tubercles, killed in 6 weeks the guinea pig which received it in the peritoneum.

Arloing⁴⁷ reports experiments with three different cultures of human origin. One of these had been in his laboratory since 1896. It was capable of infecting guinea pigs and rabbits by subcutaneous inoculation. He inoculated by intravenous injection with an emulsion of this culture a heifer, a young calf, 2 sheep, and a kid. He says that on autopsy the calf and the sheep presented a superb eruption of tuberculous granulations in all parts of the lung, principally in the anterior lobe. With the kid the lesions were more diffuse, and so extensive that the lungs scarcely collapsed when removed from the thorax. The heifer showed signs of pleural disease, for very marked excrescences were found on the borders of the lung and on their diaphragmatic surface. A small number of tubercles were found scattered through the lung. With the second culture he inoculated intravenously a calf, 2 sheep, and a goat. The autopsy demonstrated the existence of tuberculosis of the lungs in all of these animals. With the calf there were found a multitude of small young tubercles, and the subpleural granulations slightly raised in the serous membrane were easily seen. With the sheep the lungs had but little tendency to collapse. There were many subpleural granulations and

small tubercles throughout the parenchyma. With the goat the lesions recalled those found with the sheep, but were less confluent. With an emulsion of the third culture he inoculated a young bull, 2 sheep, and a goat by intravenous injection. The bull died at the end of 32 days. It was considerably emaciated, having lost 35 kilograms. The anterior and median lobes of the two lungs were studded with tubercles of various sizes, the largest being the size of a millet seed. The bronchial and esophageal glands were enormous, weighing 400 grams. In the lungs of the sheep there were perceived by the touch an enormous number of small subpleural tubercles. On section there were also seen many tuberculous granulations in the depth of the parenchyma. With the goat the lesions were similar to those found in the sheep, except the granulations were smaller.

Behring⁴⁸ reports an experiment in which human sputum was injected into a guinea pig and a culture from this animal's spleen was used for inoculating a goat. An emulsion of the spleen of the goat was passed through a series of guinea pigs, and a culture obtained from the spleen of the third guinea pig was inoculated into a calf by intravenous injection. The calf died after 4 weeks, directly from the tuberculosis thus produced. At the autopsy the lungs were found in the red stage of hepatization. From these organs tubercle bacilli were recovered in large numbers. A fairly numerous collection of subpleural nodules were present, which were yellowish in color and had reached in some instances the size of peas. Tubercle bacilli were recovered readily from these nodules. The bronchial glands were swollen and tubercle bacilli were proven present within them. The liver contained fatty infiltrations, and the spleen was darkened, but scarcely enlarged. Tubercle bacilli were recovered from it, but were not numerous. The pronounced malignity of the virus in this instance is worthy of particular notice, because it concerns bacilli derived from human sputum, although they had been passed through the goat. A cow was also inoculated with a tuberculosis culture of human origin after a single passage through a guinea pig. The inoculation was made intraocularly on November 26, 1901. On January 14, 1902, the affected eye was enucleated and a pure culture was obtained from it after one passage through a guinea pig. The cow did not die at once as a result of the inoculation, but has been gradually losing ground, and was at the time the report was made in a condition of chronic disease so serious that the final outcome could not be foretold.

Dean and Todd,⁴⁹ who have recently carried out certain experiments to ascertain whether the tubercle bacillus of human origin undergoes any marked change in virulence for the bovine species by passage through certain other animals, say that "the experiments show that the human tubercle bacillus is by no means innocuous to the calf, as the control animal injected directly with sputum contracted an

extensive glandular tuberculosis;" also, "as mentioned above, with reference to the infection of the pig, an important result was obtained, as the experiments conclusively prove that this animal is capable of contracting a rapidly fatal general tuberculosis as the result of inoculation with the tubercle bacillus of human origin."

These investigations are now sufficiently numerous and sufficiently harmonious in their results to establish the following conclusions:

(1) The bacillus tuberculosis found in human tuberculosis differs greatly in its pathogenic powers as obtained from different cases.

(2) Two types of tubercle bacilli may be obtained from man, namely, one which is somewhat difficult to cultivate, which grows slowly, and the bacilli of which are short, stubby, and free from beading—the so-called bovine type; and a second, which is quite easily cultivated, grows rapidly, is longer, thinner, and inclined to show beaded and curved forms—the so-called human type.

(3) Virulent cultures may be obtained from both of these types, which, when inoculated according to the methods used by Koch and upon the species of animals specified by him, produce progressive and fatal tuberculosis.

(4) The contention that human tuberculosis can not be transmitted to asses, sheep, goats, hogs, and especially to cattle, has been completely disproved.

(5) Koch's failure to produce tuberculosis in the animals named with bacilli from human sources was probably due to the use of bacilli of low pathogenic power.

THE TRANSMISSION OF BOVINE TUBERCULOSIS TO MAN.

Some interesting observations have also been made during the year with reference to the transmission of bovine tuberculosis to man. Krause reports the case of a laborer who was brought to the clinic in order to ascertain whether the trouble in his right arm was due to infection, and, if so, of how long standing. The man stated that he was a butcher, whose duty it was to remove the diseased parts of cattle killed for food. Three years previously he ran a splinter of wood from a table into his right thumb, and immediately afterwards removed the hide from a cow that had been sick. Soon his arm swelled and pained him; later it was covered with discharging ulcers of various sizes. Incisions were made in the arm, but without causing complete healing; afterwards larger incisions were made, which were successful. Pieces of gland and skin from the arm proved on examination to be tuberculous. According to the man's statement, he is of a healthy family, 30 years old, and had not previously suffered from disease. The lungs were sound, as were all the other internal organs, and his mind was clear. The reporter thinks there is no doubt whatever that this was

a case of inoculation tuberculosis traceable directly to the splinter wound on the thumb.

Ravenel⁶⁰ reported, in his address at the British Congress on Tuberculosis, the case of his assistant, who was inoculated with bovine tuberculosis, and from whose tissues bacilli were recovered after 58 days which retained the activity of the original bovine virus.

Quite recently Spronck and Hoefnagel⁶¹ recorded the following case: In May, 1900, a veterinarian accidentally wounded with a knife the finger of a butcher who was assisting him in inspecting the tuberculous organs of a cow. The wound healed promptly, but was followed in a few days by tumefaction and the formation of cracks in the skin. The skin of the finger became thickened and blue in color and the cracks covered with little scabs. In February, Professor Nareth extirpated the affected portion of the skin, together with the tumefied cubital ganglia. The tuberculous nature of the cutaneous lesions, as well as that of the hypertrophied ganglia, was easily recognized both by microscopic examination and by the inoculation of guinea pigs. A calf previously tested with tuberculin was placed in a newly constructed stable, in which no animal had been kept, and inoculated with an emulsion made from the spleen of one of these guinea pigs. Five days after the inoculation a swelling was noticed, and in a few days the superficial cervical ganglia were visibly tumefied. The animal soon exhibited constitutional symptoms, remained lying down most of the time, and drank excessively. The swelling increased rapidly and the animal was slaughtered 57 days after the inoculation. At the autopsy there was found at the point of inoculation on the right side of the neck a tuberculous granuloma the size of a fist inclosing at its center a large cavity filled with a soft, cheesy mass. The neighboring superficial ganglia were found granulomatous, hypertrophied, and hard. The pleura and the visceral folds presented numerous tubercles, varying in diameter from 1 to 6 mm. The tissue of the lungs was also the seat of numerous tubercles of similar size, each showing an inflammatory areola. The bronchial and mediastinal glands were hypertrophied, and on section showed caseous, noncalcified contents. Similar conditions were found in the organs generally throughout the body. Microscopic examination demonstrated that the tuberculous foci contained abundant giant cells and numerous tubercle bacilli. Finally, 2 guinea pigs which had been inoculated with material from the hypertrophied cervical ganglia—1 in the peritoneum and the other beneath the skin—died of tuberculosis. The bacilli had consequently retained their virulence for a period of 20 months, during which they lived in human tissues. These observations, according to the authors, leave no doubt as to the possibility of the infection of man with bovine tuberculosis, and they

hold that cases of contagion from the use of milk, butter, and meat of tuberculous cattle are not so rare as Koch and Baumgarten maintain.

Lassar⁵² was impelled by Koch's statements to examine closely the records of his patients during the past decade to determine how many of those that were suffering from verrucose tuberculosis of the skin of the hands could have been infected by means of injuries received in handling tuberculous meats. He found 34 cases of tuberculosis following wounds in 108,000 patients, but only 4 of this number were butchers. He later questioned and examined 365 men who were employed in abattoirs, and found 7 suffering from inoculated tuberculosis, while 3 others must be considered as possibly affected. This shows 2 to 3 cases to each 100 men employed in the abattoirs, and only one-third of 1 per 1,000 among persons otherwise employed.

Hüls⁵³ reports a case of a miller's family in good circumstances near Manderschied, composed of the miller, his wife, five sons, and two daughters, all herculean in stature and boastful of strength and health. Consumption had never occurred in the families of either of the parents. The mother became affected with pulmonary catarrh, which aroused a suspicion of tuberculosis, but after a few months she was again healthy. During the following year the 13-year-old daughter became ill of pulmonary tuberculosis and died. The same year an 18-year-old son died, and the following year a 23-year-old son. Two years after her first illness the mother sickened and died; then followed the death of a 16-year-old daughter, then the father, and finally the third son, all of pulmonary tuberculosis. For one of the two remaining sons a tuberculous abscess of the finger was treated, which healed. These two men are still living. Hüls thinks that the view of contagion from the sick members of the family can not be held, since there was practically no contact. These cases appeared subsequently to the introduction by the miller of a herd of Simmenthal cattle on his farm. These cattle were all practically infected with tuberculosis, and it was scarcely possible to dispose of the meat on account of its infected condition. Many of the carcasses were returned on account of being tuberculous, so that later the owner was compelled to sell the cattle without a guaranty as to their condition.

Considering these facts, in connection with those of similar bearing previously reported, it may be said that the transmission of bovine tuberculosis to man is fairly well established. The apparent inoculation of a human subject with bovine tubercular material, the development of a tubercular process at the point of inoculation, the isolation from the human tissues months afterwards of a tubercle bacillus having the characteristics of the bovine bacillus, constitute a chain of evidence that is conclusive.

INVESTIGATIONS BEARING UPON INTESTINAL INFECTION.

Heller⁵⁴ has made an investigation as to the comparative frequency of primary intestinal tuberculosis. He says that it is well known that tuberculosis frequently appears after diphtheria, and he therefore investigated to determine first how often tuberculosis was present before the attack of diphtheria, and, second, how often the primary lesions were located in the intestine.

Sections were made from 714 victims of diphtheria, and among these 140, or 19.6 per cent, were found to have an associated affection of tuberculosis in various organs.

2, or 1.43 per cent, showed primary intestinal tuberculosis.

8, or 5.7 per cent, showed primary intestinal and mesenteric gland tuberculosis.

33, or 23.5 per cent, showed primary mesenteric gland tuberculosis.

43, or 30.7 per cent, of all the tuberculosis cases.

43, or 6 per cent, of all the diphtheria cases.

10, or 7.1 per cent, had mesenteric gland tuberculosis, with affection of other abdominal organs.

53, or 37.8 per cent, of all tuberculosis cases.

53, or 7.4 per cent, of all diphtheria cases.

In addition to these, there were 6 other cases affected with tuberculosis of the intestines or of the mesenteric glands, together with a tubercular affection of the lungs.

With 30.7 per cent of so many tuberculosis cases showing primary lesions in the intestines or mesenteric glands, the argument against infection by ingestion of tuberculous food which was raised by Koch and based upon German statistics appears to be greatly weakened.

Gottstein,⁵⁵ in a recent statistical study relative to the etiology of tuberculosis, concludes that among children in Berlin the mortality of those at the breast is but slightly more than half as much from tuberculosis as among those otherwise nourished, the proportion, as he finds it, being as 6 to 10. He also finds, in studying the statistics of 23 large cities and university cities, where the returns are especially reliable, that whereas there has been a reduction of the mortality at all ages from tuberculosis, this reduction has been distinctly less in children under 15 years of age than in persons over that age. From this he concludes that "the thought is not to be set aside that in the etiology of tuberculosis in children and in grown people very important differences must occur. There must be assumed for the infection of children another source than for that of grown people, and it certainly is natural to conclude from the difference established statistically that the source of children's tuberculosis is to be sought partly in nourishment with milk containing tubercle bacilli, while the decrease since

1894 is to be traced back to the better general and individual prophylaxis in the care of milk."

An examination of the vital statistics of Massachusetts and Michigan, the only States from which sufficiently complete records were received, indicates a tendency of the same nature in the development of tuberculosis in the United States. In the Vital Statistics of Massachusetts, 1853-1895, the 2 years 1856-1857 are contrasted with the 2 years 1894-1895. In the 2 years first mentioned, for the period under 5 years of age, there were 46.3 deaths from pulmonary phthisis to 1,000 deaths from all causes. In the 2 years last mentioned there were but 15.6 deaths from pulmonary phthisis to 1,000 deaths from all causes, or one-third as many. This is a very gratifying reduction in the phthisis death rate. Let us see, now, how it is with other forms of tuberculosis. In the 2 years first mentioned there were in the same age class 70.7 deaths from other forms of tuberculosis to each 1,000 deaths from all causes; and in the 2 years last mentioned there were 96.2 deaths from other forms of tuberculosis to each 1,000 deaths from all causes. That is, in this 40 years there appears to have been an increase of 36 per cent in the forms of tuberculosis other than phthisis in the class under 5 years of age, while there was a reduction in the mortality of phthisis at all ages of about 45 per cent. The vital statistics of Michigan show that in that State during the years 1870 to 1884, inclusive, taking the class under 5 years of age, there were for each 100 deaths from consumption 81.8 deaths from other forms of tuberculosis; during the years 1885 to 1897, inclusive, there were 104.3 deaths from other forms of tuberculosis to each 100 from consumption, while during the 3 years 1898 to 1900, inclusive, there were 263.3 deaths from other forms of tuberculosis to each 100 from consumption. Why this tremendous increase in mortality from other forms of tuberculosis as compared with consumption at what has well been called the milk-drinking age of life?

Another important question which was discussed by your committee in its last report has reference to the possibility and frequency of tubercular infection through contaminated food when the primary lesions are elsewhere than in the abdominal cavity. The frequency with which infection may occur through the walls of the upper air passages, and particularly those of the naso-pharynx and pharynx, was shown. From recent experiments it appears that there is very likely another channel by which such infection may readily occur. It is a common observation that tubercle bacilli may penetrate the intestine and produce tubercles in the mesenteric glands without causing any lesions at the point where they pass through the intestinal wall. It has been frequently held, however, that they could not enter the thoracic duct and the blood vessels without first passing through and being arrested by a lymphatic gland.

Dobroklonski⁵⁶ in 1890 conducted some investigations from which he concluded that tuberculosis may certainly affect the organism by the digestive tract. For this infection to occur it is not necessary that there should exist a lesion of the intestinal wall, an epithelial desquamation, nor any local modification whatever, nor an interior inflammatory process. The tubercular virus (bacilli as well as spores) may easily traverse the completely normal epithelial lining of the intestine. The tubercle bacilli as well as their spores, unless they remain a long time in contact with the intestinal wall, are not capable of causing inflammatory processes in this wall, nor modifications of the epithelial coat.

In 1895, Desoubry and Porcher⁵⁷ made investigations with dogs to learn if microbes of various kinds may pass through the intestinal wall and enter the thoracic duct. They took chyle directly from the cistern of Pecquet, and also blood from the portal vein. In both cases they demonstrated the presence of bacteria. The species were not determined, but they observed cocci, bacteria, and bacilli. They say, in conclusion, that it seems to follow from their experiments that microbes may follow the lumen of the chyle vessels. Every time that the animal received either fat or milk they constantly found bacterial species in the chyle. They ask, May we not infer from this that the microbes pass into the chyle vessels by means of the globules of fat?

Quite recently Nicolas and Descos⁵⁸ have experimented in a similar manner after feeding tubercle bacilli to dogs. These investigators fed a soup composed of from 1 to 1½ liters of milk, according to the size of the animal, from 80 to 100 grams of fat, and about 100 grams of bread to dogs which had fasted 24 to 36 hours. The animals were killed from 3 to 3½ hours later. The chyle for examination was taken from the cistern of Pecquet or the thoracic duct. After each experiment a complete autopsy was made to assure the authors that the animal did not possess any tuberculous lesion and that the intestine was perfectly normal. The presence of tubercle bacilli was demonstrated by the coloration of the microscopic preparations and by the inoculation of guinea pigs. Positive results were obtained by both methods. The authors conclude as follows: The essential fact brought out by these experiments is that 3 hours after the ingestion of tubercle bacilli the chyle and the lymph of the thoracic duct may contain bacilli and even virulent bacilli in a sufficient number to cause tuberculosis in the guinea pig. They think it quite interesting to know that this may occur under conditions which approach quite closely those of a child fed with tuberculous milk.

To recapitulate, recent investigations show that—

(1) While the bacilli of human tuberculosis are often of feeble virulence for cattle, there is a considerable proportion of cases in which these bacilli are virulent for cattle as well as other animals.

(2) Bacilli of both the bovine type and the human type have been obtained from cases of human tuberculosis.

(3) Bovine bacilli introduced into the human tissues by accidental inoculation have lived, multiplied, and produced disease at the point of inoculation, and have been recovered after a considerable time with their vitality and virulence unimpaired.

(4) Various statistical studies indicate that a considerable proportion of the cases of human tuberculosis, and particularly with children, originate through the ingestion of the bacilli with contaminated food.

It appears to your committee, therefore, that the conclusions of Koch, announced at the British Congress on Tuberculosis, to the effect that bovine and human tuberculosis are different, that human tuberculosis can not be conveyed to cattle, and that man is insusceptible to bovine tuberculosis are disproved and should no longer have weight with sanitarians. The evidence brought forward indicates that greater care should be exercised to prevent human infection with bovine tuberculosis, and particularly to guard children from tuberculous milk.

BOVINE TUBERCULOSIS AFFECTING THE PUBLIC HEALTH. (Third report.)^a

By D. E. SALMON, D. V. M.,

Chief of the Bureau of Animal Industry and Chairman of the Committee on Animal Diseases and Animal Food of the American Public Health Association.

Your committee on animal diseases and animal food have the honor to make the following report with reference to tuberculosis, and regret that the time at the chairman's disposal has not permitted the inclusion of other subjects which are also of great interest at this time.

In the last two reports presented by this committee considerable space was devoted to the subject of tuberculosis, and particularly to that phase of it which relates to the transmission of the disease from animals to man. It was shown from a review of the facts obtained by different methods of inquiry that the clinical evidence, the evidence of statistics, and the evidence from experimental researches all favored the conclusion that animal tuberculosis was a factor in the causation of human tuberculosis, and it was held that sanitarians should advocate and enforce measures to prevent the transmission of the disease from animals to man. This question is so important and so much uncertainty has been caused by the paper presented at the British Congress on Tuberculosis by Koch,² and by his subsequent address at the International Conference on Tuberculosis at Berlin,³ that it is deemed advisable to continue the discussion in the present report.

The fact that tubercular material from human subjects often failed to produce serious disease in cattle was observed by a number of the earlier investigators who experimented with such virus. It was the experiments and comparative studies of Theobald Smith, however, which attracted special attention to the difference in virulence shown by tubercle bacilli from human and bovine sources when inoculated upon cattle. Smith⁴ mentioned also certain morphological and cultural differences in bacilli from these two sources, and in the location and histology of the lesions in cattle produced by such bacilli. He did not conclude, however, that bovine bacilli could not produce disease in the human subject, but said:

It seems to me that, accepting the clinical evidence on hand, bovine tuberculosis may be transmitted to children when the body is overpowered by large numbers of bacilli, as in udder tuberculosis, or when certain unknown favorable conditions exist.

^aReport of committee on animal diseases and animal food to the American Public Health Association, at Washington, D. C., October 26-30, 1903.

that human tuberculosis is not transmissible to cattle. Again, how are we to explain the human cultures of medium virulence? Are they human bacilli which, for some unknown reason, are increasing in virulence and approaching the activity of the bovine bacillus? Or are they really bovine bacilli which have multiplied in the human body until their virulence has become attenuated? In whatever manner these questions are decided it would seem that the findings of the German commission, instead of supporting Koch's views that we can decide with certainty by the inoculation of cattle as to the source of any given bacillus, really show that this method of diagnosis is extremely uncertain in the present condition of our knowledge.

It is definitely admitted that 4 of the human cultures caused generalized tuberculosis in cattle; but Kossel suggests that it might be possible that the bacilli in cases of human tuberculosis under certain circumstances could likewise attain a very high pathogenic activity for cattle without being for that reason bovine bacilli. Undoubtedly the German commission is confronting the two horns of a dilemma, either one of which is fatal to the views of Koch as stated with such positiveness at London. If we accept this suggestion thrown out by Kossel, we must conclude that Koch was wrong in his claim that human tuberculosis can not be transmitted to cattle, and thus with one blow we destroy the entire experimental support which he had for his argument before the British Congress on Tuberculosis. And if, on the other hand, we accept the conclusion which follows from the principle laid down by Koch for the discrimination between human and bovine bacilli, and which appears to be favored by Kossel, we must admit that bovine tuberculosis is an extremely important factor in the etiology of human tuberculosis. Of the 39 cases of human tuberculosis tested, 4, or over 10 per cent, were virulent for cattle and would be classified as of bovine origin; but these 4 cases were all found among the 16 cases of tuberculosis in children which the commission investigated; hence it is plain that 25 per cent of the cases tested of tuberculosis in children would by Koch's method be classified as of bovine origin.

In the Bureau of Animal Industry two distinct lines of experiments have been carried on, in order that one might serve as a check against the other. There has been, however, no discrepancy in the results. De Schweinitz,³⁰ in the Biochemic Division, Bureau of Animal Industry, has isolated 9 cultures from human tuberculosis. Two of these were derived from human sputum, 3 from cases of generalized tuberculosis in adults, and 4 from cases of generalized tuberculosis in children. By comparing these cultures with a newly isolated virulent culture of bovine tuberculosis, there were found among them 2 cultures from children which were identical in their cultural and morphological characters with the bovine bacillus. These cultures also killed rabbits

and guinea pigs in as short a time as did the bovine bacillus. Hogs which were inoculated subcutaneously with these 2 cultures from children died of generalized tuberculosis. Two calves, weighing over 300 pounds each, were inoculated subcutaneously with these virulent human cultures, and as a result developed generalized tuberculosis. A yearling heifer inoculated with 1 of the cultures showed generalized tuberculosis when killed 3 months after inoculation. Both the cattle and the hogs had been tested with tuberculin and found to be free from tuberculosis before the inoculations were made. It is important to observe in this connection that 2 out of 4, or 50 per cent, of the cultures obtained from cases of generalized tuberculosis in children proved virulent for cattle.

Mohler,²⁸ working in the Pathological Division, Bureau of Animal Industry, has obtained 3 very virulent cultures of tubercle bacilli from the human subject. A goat inoculated subcutaneously with 1 of these cultures died in 37 days with miliary tuberculosis of the lungs involving the axillary and prescapular glands. This bacillus was obtained from the mesenteric gland of a boy. Of still greater interest is a bacillus isolated by Mohler from human sputum. A goat inoculated subcutaneously with a culture of this germ died in 95 days of pulmonary tuberculosis. A cat inoculated in the same manner died in 23 days of generalized tuberculosis. A rabbit similarly inoculated died in 59 days of pulmonary tuberculosis. Another rabbit inoculated with a bovine culture for comparison lived 10 days longer than the one inoculated with this sputum germ. Mohler also inoculated subcutaneously a 1-year-old heifer with a culture derived from the tubercular mesenteric gland of a boy 4 years of age. This culture was always refractory in its growth under artificial conditions, and the bacilli were short, stubby rods corresponding in appearance with the bovine type. At the autopsy, held 127 days after the inoculation, the general condition was seen to be poor and unthrifty, and large, hard tumors were found at the points of inoculation. On the right side the swelling measured $3\frac{1}{2}$ by 5 inches, and the corresponding lymph gland was $2\frac{1}{4}$ inches long by $1\frac{1}{4}$ inches in diameter. This gland contained numerous calcareous foci; one of these at the apex was an inch in diameter. The lesions on the left shoulder of the animal were very similar to those found on the right side, but the dimensions of the tumor were slightly less. The lungs presented an irregular mass of tubercular nodules, and 7 or 8 grape-like nodules were seen on the parietal pleura. Bronchial and mediastinal lymph glands contained numerous tubercular foci, and the pericardium, peritoneum, spleen, and liver were also affected.

In order to throw some light, if possible, upon the morphological constancy of the different types of tubercle bacilli, Mohler was requested by the chairman of your committee to make comparative

studies of bacilli from various sources, and which had been passed through various species of animals, by making the cultures upon dog serum after the method described by Theobald Smith. Some important results have been obtained. One culture of human bacilli which had morphological and cultural peculiarities similar to those of the bovine bacillus, and which only produced local lesions in cattle, was passed through a series of 5 cats. It was then found to be completely changed in its morphological characters, the rods being elongated, slender, more or less beaded, and entirely of the human type. But far from decreasing in virulence, as might be expected from its morphological appearance, this bacillus had so increased in its pathogenic activity that it now produced generalized tuberculosis in a cow. This cow was inoculated subcutaneously in front of each shoulder with 2 c. c. of a salt solution emulsion of the tuberculous omentum of the last cat of the series. The cow rapidly lost flesh, had a temperature of 104° F., with the point of inoculation and adjacent glands greatly swollen. The autopsy revealed generalized tuberculosis, involving the lungs, mediastinal glands, spleen, liver, and kidneys. Tubercle bacilli of the bovine type obtained from the mesenteric glands of a sheep, hog, and cow were similarly transformed in their morphological appearance after being passed through a series of cats and recovered on dog serum. These bacilli also increased in virulence, as the last cat in the series invariably succumbed in a shorter time than the first of the series.

These experiments and observations indicate that the types of tubercle bacilli are very inconstant, and that under suitable conditions they readily change both in morphology and in virulence. A similar conclusion was reached by other investigators in working with the avian and piscine types of tubercle bacilli several years ago, and was reasonably to have been expected with the human and bovine types.

It must be plain to all, from these recent developments, that too much has been made of the slight differences in cultural characteristics, in morphology, and in virulence which have been observed in some cases in comparing the human and the bovine bacilli. The observations were interesting, and it was important that they should be followed up until their significance was made entirely clear; but it was an almost unpardonable error, from a sanitary point of view, to promulgate sweeping generalizations calculated to arrest and abolish important measures for preventing human tuberculosis before the soundness of these generalizations had been established by a thorough course of experimentation.

When Koch said in the British Congress on Tuberculosis that he should estimate the extent of infection by the milk and flesh of tubercular cattle and the butter made of their milk as hardly greater than that of hereditary transmission, and that he therefore did not deem it

advisable to take any measures against it, he went far beyond what was justified by any experiments or observations which he reported, and he did an immense amount of harm which will be manifested for years to come to those who endeavor to guard the human race from the dangers of animal tuberculosis. The researches to which your committee has alluded make these dangers more definite and certain than they have appeared before, and sanitarians should therefore most earnestly endeavor to counteract the erroneous and harmful impression which was made by Koch's address at London and his subsequent address at the International Conference on Tuberculosis at Berlin.

Now that the conclusions of the London address are shown to be incorrect and based on insufficient experimentation, it is well that some attention should be given to the Berlin address, in which certain rules were laid down for testing all clinical evidence before it can be accepted as indicating the transmission of tuberculosis from animals to man. While your committee agrees that it is advisable to scrutinize clinical evidence as carefully as possible before it is accepted as influencing the decision of such an important question, consistency demands that we should accept clinical evidence bearing upon the transmission of bovine tuberculosis to man on the same terms that we accept evidence bearing upon the transmission of tuberculosis from man to man. For instance, Koch said in his London address, "So the only main source of the infection of tuberculosis is the sputum of consumptive patients." How does he know this? Has he any evidence to support this conclusion which will stand the requirements which he has laid down for those who oppose his views with reference to the transmission of animal tuberculosis to man? If so, this evidence has not yet been presented. Your committee believes that the principal source of tuberculosis in man is infection from other tuberculous human subjects, but it also believes that a considerable proportion of the cases of tuberculosis in man is due to infection from animal sources; and in weighing the evidence by which we are to fix more rigorously the relation which these two sources of infection bear to each other it is logical that we should apply the same rules of evidence in each case.

The rules which Koch formulated for testing the evidence as to bovine infection are given below, with such brief comments as your committee feels they deserve:

(1) Certain proof of tubercle, and where possible the primary focus must be supplied.

To this condition no objection is raised, but it should be remarked that the location of the primary focus, which is made so much of, is of little value in determining the origin of the infection. It has been clearly shown by various investigators, whose work has been referred to in the preceding reports of this committee, that tubercle bacilli may pass through the walls of the intestine without producing any lesion at the point of entrance, and that their first point of lodgment and

multiplication may be the mesenteric glands, the liver, spleen, or even the lungs. On the other hand, Koch has told us that the location of the primary lesion in the intestine is of no significance, because human as well as animal bacilli may be swallowed and may be the cause of such lesions. It is therefore not at all apparent that this is an essential point.

(2) Other sources of infection must be excluded with certainty.

This condition appears to exclude all clinical evidence bearing upon the source of tubercular infection. How is it possible to prove that any given individual has not been exposed to the bacilli of human tuberculosis? And, for the same reason, how is it possible to prove that any given individual has not been exposed to the bacilli of animal tuberculosis? It may be said that this consumptive person had habitually been in a room with another consumptive patient and was infected from that patient; but how can you prove that this person never ate any tuberculous meat, never partook of any tuberculous milk, never ate any butter containing the tubercle bacillus, never had an opportunity to be indirectly infected from the hands of cooks or from table utensils which had been in contact with tuberculous meat, milk, or butter, and was never exposed to the infection scattered in so many ways by tuberculous animals? It is impossible to exclude with certainty all these sources of infection, and if we apply the condition under discussion to the evidence upon which Koch based the assertion that the main source of the infection of man is the sputum of consumptive patients we should find no part of it that would stand the test. Now, is it logical to accept clinical evidence as to the transmission of tuberculosis from man to man by one set of rules and to require an entirely different set of rules when considering evidence as to the transmission of the same disease from animals to man? Your committee is of the opinion that clinical evidence should be regarded as valuable in confirming experimental researches, or in indicating the probable facts where experimentation has been insufficient or is impossible, but that it is too much to expect that clinical evidence will be forthcoming as to the transmission of tuberculosis which will exclude all possible sources of error.

(3) In each case of alleged infection from milk affected with bovine tuberculosis the condition of the rest of the people who have taken the same milk should be borne in mind. These fellow-consumers form to a certain extent a control experiment, and if of the numerous people who have drunk the suspected milk only a single one sickens, this weighs decidedly against the belief that this one person was infected by the common food.

This condition also is regarded by your committee as illogical and impossible of general application without discarding all clinical evidence upon this question. If we apply it to the alleged cases of

sputum infection, we find it is seldom, indeed, that the disease in more than one person can be traced with any probability to the same tuberculous patient, although scores of persons may have been exposed to that patient. Most people who escape tuberculosis have nevertheless been exposed many times to tuberculous patients, but this is not sufficient reason for concluding that others have not contracted the disease by similar exposure. Tuberculosis is a disease which is communicated with such difficulty among people under ordinary conditions of life, by exposure either to diseased persons or to tuberculous food, develops so slowly, and varies so much in the period which elapses before symptoms are observed, that it is only very rarely that groups of cases are observed which even appear to have originated from the same source. And yet how erroneous it would be to exclude clinical evidence suggesting contagion because only one of those exposed to a certain consumptive patient had contracted the malady.

(4) The source of the milk should be attended to. Since in recent years it has become more and more evident that milk containing tubercle bacilli is yielded only by such cows as suffer from tuberculosis of the udders, the general statement that someone has drunk milk from a cow suffering from tuberculosis no longer suffices to prove to us that bovine tuberculosis bacilli have really reached his digestive organs. It must be from a cow with tuberculosis of the udder, and therefore a statement on this subject should not be wanting in a report on milk infection if it is said to be complete.

Your committee finds this statement of fact to be incorrect, since the tendency of recent investigations by competent persons is to make it more and more evident that cows with tuberculosis may yield milk containing tubercle bacilli when the udders present no signs of the disease. The argument is therefore antiquated. Of the many experiments that have been made to determine the proportion of tuberculous cows which yield infectious milk, the average results are about 15 per cent, while the cases of tuberculosis of the udder are about 2 per cent. In recent investigations made by Mohler, of the Bureau of Animal Industry, with 56 reacting cows, it was found that 12 of these, or 21.4 per cent, at one time or another during the experiment gave milk which contained virulent tubercle bacilli. Undoubtedly cows with tuberculosis of the udder yield milk containing a larger number of tuberculosis bacilli than do those in which the udder remains unaffected, and are therefore more dangerous, but it has been clearly shown that other tuberculous cows may yield virulent milk.

So much for the conditions laid down by Koch for testing clinical evidence bearing upon the transmission of tuberculosis from animals to man. The effort to rule out all such evidence by applying impossible tests does not meet with our approval, but fortunately clinical

evidence is no longer necessary for deciding the question. The subcutaneous injection of cattle with pure cultures of the tuberculosis bacillus from human sources, which, according to Koch, "yields quite specially characteristic and convincing results," has proved, in the hands of the German commission no less than in those of independent investigators, that bovine tuberculosis is communicable to man. It will require much work to decide with even approximate accuracy the proportion of human tuberculosis caused by animal infection; but the fact that 25 per cent of the cases in children investigated by the German commission, and 50 per cent of similar cases investigated by de Schweinitz, showed by this test that they were caused by animal infection is sufficient to convince us that measures should be taken and enforced at once to guard against infection from this source.

In concluding, your committee desires to express its appreciation of the prompt, intelligent, and indefatigable work of those scientific investigators who took up this question immediately after it was brought to the front at London, and in the comparatively short period of about two years have furnished the material for definitely settling it, so far as the principal contention is concerned.

BIBLIOGRAPHY.

- (1) Bull. No. 84, Wisconsin Agric. Exper. Station, March, 1901.
- (2) KOCH, ROBERT.
Address on the combating of tuberculosis in the light of experience gained in the combating of other infectious diseases. Trans. Brit. Cong. on Tuberculosis for Prevention of Consumption, London, July 22-26, 1901, v. 1, pp. 23-35. 1902.
- (3) CHAUVEAU, A.
L'identité de la tuberculose de l'homme et de la tuberculose du bœuf, d'après les résultats des expériences sur l'infection des sujets de l'espèce bovine par les matières tuberculeuses empruntées à l'espèce humaine. Cong. p. l'étude de la tuberculose, Paris, 2^e session, 1891, pp. 51-63. 1892.
- (4) RAVENEL, MAZŮCK P.
Three cases of tuberculosis of the skin due to inoculation with bovine tubercle bacillus. Phila. Med. Journ., July 21, 1900.
- (5) PFEIFFER, L.
Ztschr. f. Hyg., Bd. 3, p. 209. 1888.
- (6) Omaha Clinic, Feb., 1896.
- (7) Cited by Theobald Smith in Journ. Exper. Med., v. 3, p. 505, from Rev. gén. d'ophthalm., v. 15, p. 433. 1896.
- (8) Inauguration dissertation. Ztschr. f. Med.-Beamte, No. 11. 1896.
- (9) Proc. Cong. for Study of Human and Animal Tuberculosis, 1st sess., Paris, p. 275. 1888.
- (10) OSTERTAG, ROBERT.
Handbuch d. Fleischbeschau, p. 638. 1899.
- (11) Dublin Journ. Med. Sci., n. ser., v. 103, pp. 378-386. 1897. Also cited by Nocard, Les tuberculoses animales, p. 124.

- (12) Cited by Law, from Rep. Vet. Cong. Brussels, p. 288. 1883. Also cited by Nocard, from Compt. rend. 4th Internat. Vet. Cong., Brussels, p. 188. 1883.
- (13) LAW, JAMES.
Papers and addresses, New York State Vet. College, 1896-98, p. 85.
- (14) LAW, JAMES.
Papers and addresses, New York State Vet. College, 1896-98, p. 86. From Tuberculosis, National Vet. Assoc., London, 1883.
- (15) NOCARD, ED.
Les tubercules animales, p. 123.
- (16) Journ. Tuberculosis, April, 1899, p. 64.
- (17) Brit. Med. Journ., Aug. 19, 1899, p. 455.
- (18) Brit. Med. Journ., Sept. 2, 1899, p. 626.
- (19) Edinburgh Hospital Rep., 1900. Cited by Still in The Practitioner, July, 1901.
- (20) The Practitioner, July, 1901.
- (21) Quoted by Still, from Trans. Med. Soc. London, p. 292. 1894.
- (22) Quoted by Still, from The Lancet, v. 1, p. 286. 1899.
- (23) Edinburgh Hospital Rep., 1900. New York Med. Journ., Feb. 21, 1891. Cited by Still in The Practitioner, July, 1901.
- (24) New York Med. Journ., Feb. 21, 1891. Tuberculosis in children.
- (25) Lancet, London, v. 2, pp. 957-960. 1894.
- (26) Lancet, London, Sept. 17, p. 733. 1898.
- (27) Journ. Amer. Med. Assoc., Aug. 31, p. 590. 1901.
- (28) Phila. Med. Journ., Aug. 24, p. 284. 1901.
- (29) LARTIGAU, AUGUST JEROME.
A study of the variation in virulence of the bacillus tuberculosis in man. Journ. of Med. Research, Boston, No. 62, v. 6, No. 1 (n. ser., v. 1, No. 1), July, pp. 156-162. 1901.
- (30) DE SCHWEINITZ, F. A., and M. DORSET.
Experiments in the virulence of tuberculosis bacilli. Bull. No. 52, Bureau of Animal Industry. (*In press.*)
- (31) KOCH, ROBERT.
Die Aetiologie der Tuberculose. Berlin. klin. Wehnschr., 19. Jhrg., No. 15, 10. Apr., pp. 221-230. 1882.
- (32) REPORT OF COMMITTEE ON ANIMAL DISEASES AND ANIMAL FOOD.
Reports and papers, Amer. Pub. Health Assoc., Buffalo, Sept. 16-20, 1901, v. 27, pp. 45-77. Columbus, Ohio. 1902. (Also included in the present bulletin.)
- (33) BOLLINGER, O.
Ueber die Identität der Perlsucht der Rinder mit der menschlichen Tuberculose. München. med. Wehnschr., 41. Jhrg., No. 5, 30. Jan., pp. 85-86, 1 fig. 1894.
- (34) MARTIN, SIDNEY.
Influence upon animals of food of tuberculous origin: Influence upon man. Report of royal commission appointed to inquire into the effect of food derived from tuberculous animals on human health. Pt. 1, pp. 9-17. London. 1895.
- (35) VAGEDES.
Experimentelle Prüfung der Virulenz von Tuberkelbacillen. Ztschr. f. Hyg. u. Infektionskrankh., Leipzig, Bd. 28, Heft 2, pp. 276-320, figs. 1-6. 19. Aug., 1898.
- (36) SMITH, THEOBALD.
The relation between bovine and human tuberculosis. Med. News, N. Y., v. 80, No. 8, Feb. 22, pp. 343-346. 1902.

- (37) RAVENEL, MAZŮCK P.

The intercommunicability of human and bovine tuberculosis. *Medicine*, Detroit, v. 8, No. 7, July, pp. 529-546, figs. 1-5; No. 8, Aug., pp. 617-632, figs. 6-9. 1902.

- (38) (Report not yet published.)

- (39) THOMASSEN.

The receptivity of bovine animals for the bacillus of human tuberculosis. *Trans. Brit. Cong. on Tuberculosis for Prevention of Consumption*, London, July 22-26, 1901, v. 4, pp. 21-27. 1902.

- (40) DE JONG, A.

Expériences comparatives sur l'action pathogène pour les animaux, notamment pour ceux de l'espèce bovine, des bacilles tuberculeux provenant du bœuf et de l'homme. *Ann. de méd. vét.*, Bruxelles, v. 51, No. 4, avril, pp. 181-190; No. 5, mai, pp. 251-259. 1902.

- (41) DELÉPINE, SHERIDAN.

A discussion on the relationship of human and bovine tuberculosis. *Brit. Med. Journ.*, London, No. 2178, Sept. 27, p. 947. 1902.

- (42) ORTH, J.

Ueber einige Zeit- und Streitfragen aus dem Gebiete der Tuberculose. II.—Was ist Perlsucht? *Berlin. klin. Wchnschr.*, 39. Jhrg., No. 34, 25. Aug., pp. 793-798. 1902.

- (43) STENSTRÖM, OLOF.

Die Tuberculose des Menschen und der Rinder. *Ztschr. f. Thiermed.*, Jena, n. F., Bd. 6, Heft 4, pp. 289-291. 1902.

- (44) FIBIGER, JOHANNES, and C. O. JENSEN.

Uebertragung der Tuberculose des Menschen auf das Rind. *Berlin. klin. Wchnschr.*, 39. Jhrg., No. 38, 22. Sept., pp. 881-886. 1902.

- (45) WOLFF, MAX.

Perlsucht und menschlichen Tuberkulose. *Deutsche med. Wchnschr.*, Leipzig, 28. Jhrg., No. 32, 7. Aug., pp. 566-570. 1902.

- (46) NOCARD, ED.

Expériences sur la tuberculose. *Rev. vét.*, Toulouse, An. 27 (59), No. 1, 1^{er} jan., pp. 49-54. 1902.

- (47) ARLOING, S.

L'inoculabilité de la tuberculose humaine et les idées de M. Robert Koch sur cette tuberculose et la tuberculose animale. *Bull. Acad. de méd.*, Paris, v. 65, 3. sér., v. 46, No. 43, 24 déc., pp. 897-911. 30 déc., 1901.

- (48) BEHRING, E. v., P. RÖMER, and W. G. RUPPEL.

Tuberkulose. xviii, 90 pp. Marburg. 1902. (*In Beiträge zur experimentellen Therapie*, Heft 5, Theil 1, Text und Anlage.)

- (49) DEAN, GEORGE, and CHARLES TODD.

Abstract of certain experiments on tuberculosis. *The Lancet*, London, No. 4131, v. 163, No. 18 (v. 2, 1902), Nov. 1, pp. 1186-1187. 1902.

- (50) RAVENEL, MAZŮCK P.

Discussion on tubercle bacilli in cows' milk as a possible source of tuberculous disease in man. *Trans. Brit. Cong. on Tuberculosis for Prevention of Consumption*, London, July 22-26, 1901, v. 1, pp. 91-92. 1902.

- (51) SPRONCK, C. H. H., and K. HOEFNAGEL.

Transmission à l'homme, par inoculation accidentelle, de la tuberculose bovine, et réinoculation expérimentale au veau. *La Semaine méd.*, Paris, An. 22, No. 42, 15 oct., pp. 341-343, figs. 1-4. 1902.

- (52) LASSAR, O.
Ueber Impftuberkulose. Deutsche med. Wchnschr., Leipzig, 28. Jhrg., No. 40, 2. Oct., pp. 716-718. 1902.
- (53) HÜLS.
Zur Frage der Uebertragung der Rindertuberkulose auf den Menschen. München. med. Wchnschr., 49. Jhrg., No. 24, 17. Juni, pp. 1003-1004. 1902.
- (54) HELLER, ARNOLD.
Kleine Beiträge zur Tuberkulose-Frage. München. med. Wchnschr., 49. Jhrg., No. 15, 15. Apr., pp. 609-611. 1902.
- (55) GOTTSTEIN, A.
Statistische Beiträge zur Verbreitung der Tuberkulose. München. med. Wchnschr., Bd. 48, No. 41, 8. Okt., pp. 1610-1612, tables 1-4b. 1901.
- (56) DOBROKLONSKI, V.
De la pénétration des bacilles tuberculeux dans l'organisme à travers la muqueuse intestinale et du développement de la tuberculose expérimentale. Arch. de méd. expér. et d'anat. path., Paris, 1. sér., v. 2, pp. 253-271. 1890.
- (57) DESOUBRY, G., and CH. PORCHER.
De la présence de microbes dans le chyle normal chez le chien. Compt. rend. Soc. de biol., Paris, v. 47, 10. sér., v. 2, No. 5, 15 fév., pp. 101-104. 1895.
- (58) NICOLAS, J., and A. DESCOS.
Passage des bacilles tuberculeux après ingestion dans les chylifères et le canal thoracique. Journ. de physiol. et de path. gén., Paris, v. 4, No. 5, 15 sept., pp. 910-912. 1902.
- (59) KOCH, ROBERT.
Menschen- und Thiertuberkulose. Bericht erste Internat. Tuberk.-Konf., Berlin, 22.-26. Oct., 1902, pp. 348-361. 1903.
Translation. In Brit. Med. Journ., London, No. 2190, v. 2, Dec. 20, pp. 1885-1889. 1902.
- (60) SMITH, THEOBALD.
A comparative study of bovine tubercle bacilli and of human bacilli from sputum. Journ. Exper. Med., v. 3, p. 506. 1898.
- (61) KOSSEL, H.
Mittheilungen über Versuche an Rindern mit Tuberkelbacillen verschiedener Herkunft. Berlin. klin. Wchnschr., 40. J., No. 29, 20. Juli, pp. 653-657. 1903.

(Continued from second page of cover.)

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF ANIMAL INDUSTRY—BULLETIN NO. 54.

D. E. SALMON, D. V. M., Chief of Bureau.

LAWS

(FEDERAL, STATE, AND TERRITORIAL)

RELATING TO

CONTAGIOUS AND INFECTIOUS DISEASES OF ANIMALS.

1902 and 1903.



WASHINGTON:
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1904.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., December 1, 1903.

SIR: I have the honor to transmit herewith copies of such Federal, State, and Territorial laws relating to contagious and infectious diseases of animals as were enacted during the years 1902 and 1903, and recommend that they be published as Bulletin No. 54 of this Bureau. Prior to 1901 it had been the custom to publish these laws biennially in the report of this Bureau, but the laws of 1900 and 1901 were published separately in bulletin form so as to avoid taking up the much-needed space of the report. The present bulletin, therefore, is designed to be a continuation of Bulletin No. 43 of this Bureau, which contained the aforesaid laws of 1900 and 1901.

Respectfully,

D. E. SALMON,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary.

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LAWS FOR THE CONTROL OF CONTAGIOUS DISEASES OF ANIMALS.

UNITED STATES.

AN ACT To enable the Secretary of Agriculture to more effectually suppress and prevent the spread of contagious and infectious diseases of live stock, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled:

Transfer of power to regulate transportation of animals.

SECTION 1. That in order to enable the Secretary of Agriculture to effectually suppress and extirpate contagious pleuro-pneumonia, foot-and-mouth disease, and other dangerous contagious, infectious, and communicable diseases in cattle and other live stock, and to prevent the spread of such diseases, the powers conferred on the Secretary of the Treasury by sections four and five of an act entitled "An act for the establishment of a bureau of animal industry, to prevent the exportation of diseased cattle, and to provide means for the suppression and extirpation of pleuro-pneumonia and other contagious diseases among domestic animals," approved May 29, 1884 (23 U. S., 31), are hereby conferred on the Secretary of Agriculture, to be exercised exclusively by him. He is hereby authorized and directed, from time to time, to establish such rules and regulations concerning the exportation and transportation of live stock from any place within the United States where he may have reason to believe such diseases may exist, into and through any State or Territory, including the Indian Territory, and into and through the District of Columbia and to foreign countries, as he may deem necessary, and all such rules and regulations shall have the force of law.

State inspection and fees abolished.

Whenever any inspector or assistant inspector of the Bureau of Animal Industry shall issue a certificate showing that such officer had inspected any cattle or other live stock which were about to be shipped, driven, or transported from such locality to another, as above stated, and had found them free from Texas or splenic fever infection, pleuro-pneumonia, foot-and-mouth disease, or any other infectious, contagious, or communicable disease, such animals, so inspected and certified, may be shipped, driven, or transported from such place into and through any State or Territory, including the Indian Territory, and into and through the District of Columbia, or they may be exported from the United States without further inspection or the exaction of fees of any kind, except such as may at any time be ordered or exacted by the Secretary of Agriculture; and all such animals shall at all times be under the control and supervision of the Bureau of Animal Industry of the Agricultural Department for the purposes of such inspection.

Authority to prevent introduction and spread of disease.

Sec. 2. That the Secretary of Agriculture shall have authority to make such regulations and take such measures as he may deem proper to prevent the introduction or dissemination of any contagious, infectious, or communicable disease of animals from a foreign country into the United States or from one State or Territory of the United States or the District of Columbia to another, and to seize, quarantine, and dispose of any hay, straw, forage or similar material, or any meats, hides, or other animal products coming from an infected foreign country to the United States, or from any State or Territory or the District of Columbia in transit to another State or Territory or the District of Columbia, whenever in his judgment such action is advisable in order to guard against the introduction or spread of such contagion.

Penalty. SEC. 3. That any person, company, or corporation knowingly violating the provisions of this act or the orders or regulations made in pursuance thereof shall be guilty of a misdemeanor, and on conviction shall be punished by a fine of not less than one hundred dollars (\$100) nor more than one thousand dollars (\$1,000), or by imprisonment not more than one year, or by both such fine and imprisonment.

Approved February 2, 1903.

AN ACT Making appropriations for the Department of Agriculture for the fiscal year ending June thirtieth, nineteen hundred and four.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled:

* * * * *

Appropriation to stamp out foot-and-mouth disease.

contagious diseases of animals, to be used for no other purpose, five hundred thousand dollars (\$500,000).

Approved March 3, 1903.

EMERGENCY APPROPRIATION: To enable the Secretary of Agriculture to stamp out and eradicate the foot-and-mouth disease and other

COLORADO.

AN ACT Appropriating the sum of two thousand one hundred dollars, or so much thereof as may be necessary, to pay certificates in full heretofore issued by or under the authority of the State veterinary sanitary board for diseased animals killed by order of such board.

Be it enacted by the General Assembly of the State of Colorado:

Appropriation for diseased animals killed.

(\$2,100), or so much thereof as may be necessary, to make payment in full of any and all outstanding and unpaid certificates issued by or under the authority of the State veterinary sanitary board, for diseased animals heretofore killed by order of said board.

SECTION 1. That there is hereby appropriated, out of any funds in the treasury not otherwise appropriated, the sum of two thousand one hundred dollars (\$2,100), to make payment in full of any and all outstanding and unpaid certificates issued by or under the authority of the State veterinary sanitary board, for diseased animals heretofore killed by order of said board.

Method of payment.

SEC. 2. Upon presentation and surrender of said outstanding certificates the auditor of state is hereby authorized and directed to draw warrants in favor of the holders and owners of said certificates for the full amount of said certificates, respectively; such warrants, however, not to exceed in all the sum of two thousand one hundred dollars (\$2,100), and said warrants shall be paid by the State treasurer upon presentation thereof to him, out of any moneys in the State treasury not otherwise appropriated.

Emergency clause.

SEC. 3. In the opinion of the general assembly an emergency exists; therefore, this act shall take effect and be in force from and after its passage.

Approved April 14, 1903.

AN ACT To establish a State board of stock inspection commissioners, to prescribe their duties and powers, to provide for the inspection of live stock before shipment by railroad or removal beyond the boundaries of this State, to provide for the sanitary inspection of live stock and for quarantine against infectious diseases in live stock, to provide penalties for the violation of the provisions of this act, and to repeal all acts and parts of acts in conflict therewith.

Be it enacted by the General Assembly of the State of Colorado:

Governor to appoint 9 commissioners for stock inspection.

inspection commissioners, of whom five shall be actual and practical cattle men, three actual and practical sheep men, and one an actual and practical horse man. Only such men shall be eligible to serve on said board as are actual owners of cattle, sheep, or horses in the State of Colorado, and whose main industry and occupation is the live-stock business, and the person or persons chosen to represent the cattle, sheep, or horse interests shall be mainly engaged, respectively, in the cattle, sheep, or horse industry. Such commissioners shall be appointed for the term of two years, which term shall commence May 1, 1903, and biennially thereafter.

SECTION 1. The governor shall appoint, upon the passage and approval of this act, nine commissioners, to be known as the State board of stock

Commissioners shall receive no salary.

SEC. 2. The members of the State board of stock inspection commissioners shall receive no salary or emolument whatsoever.

Powers of board of commissioners.

SEC. 3. Said board shall make such rules and regulations touching the manner of inspection of brands and live stock, and affecting quarantine and sanitary conditions, as they shall deem proper; provided, that the same do not conflict with this act.

Officers of the board. Salary of secretary.

SEC. 4. There shall be chosen at the first meeting of said board a president, a secretary, and a treasurer thereof. The president shall be one of the members of said board, and shall preside at the meetings of the board and perform such other duties as may be delegated to him by the board as the chief officer thereof. The secretary shall enter into a bond, to be approved by said board, running to the people of the State of Colorado, in the sum of five thousand dollars (\$5,000), conditioned for the faithful performance of duty, which said bond shall be filed with the secretary of state. The secretary of said board shall devote his entire time and attention to the business of said board, and shall keep accurate records of all transactions thereof, as well touching the inspection of live stock and quarantine regulations as all matters and things done by said board, and all moneys received and expended by said board. It shall be his duty, immediately upon the receipt thereof, to turn over to the treasurer of said board all moneys which may come into his hands as such secretary, and shall annually file in the office of the governor of the State a statement of the acts and doings of said board for the previous year. The secretary shall receive as compensation the sum of fifteen hundred dollars (\$1,500) per year, to be paid out of the inspection fund by warrants drawn monthly upon the State treasurer by the State auditor.

Treasurer of board, bond and duties.

SEC. 5. The treasurer shall be chosen from the members of said board and shall enter into bond for ten thousand dollars (\$10,000), conditioned as provided for the secretary by section four of this act, which said bond shall be filed with the secretary of state.

It shall be the duty of the said treasurer to receive and account for all moneys and funds of whatsoever character coming into the charge and custody of said board, or the secretary thereof, and to disburse and pay out the same upon proper orders and warrants issued by said board, and to keep accurate and exact accounts of the same, and to render said board once in every six months, or oftener if required by said board, full, complete, and accurate statement of all moneys or funds received by him, all sums paid out or disbursed, and showing the balance in his hands, and the source from which all moneys were received, and on what account the same were paid out, and to what fund the balance, if any, belongs.

Appointment and salary of stenographer.

SEC. 6. It shall be the duty of the board of stock inspection, at the first meeting of said board, to appoint a competent stenographer to assist the secretary of said board, which stenographer shall receive not to exceed nine hundred dollars (\$900) per annum, to be paid in monthly warrants drawn by the State auditor and to be paid by the State treasurer from the stock-inspection fund.

Appointment of inspectors, salary and bond.

SEC. 7. The said board shall have full authority and power to appoint such regular and special brand and sanitary inspectors as they shall deem expedient and necessary for the proper protection of the live-stock interests of the State. All said inspectors shall be under the control and direction of said board, and subject to its rules and regulations. As compensation for their services the regular brand inspectors shall receive not to exceed one hundred dollars (\$100) per month, and the auditor of state shall draw his warrant therefor upon vouchers approved by the president and secretary of said board, and the State treasurer shall pay the same out of the inspection fund: *Provided*, That no voucher shall be drawn by said board in excess of the amount of money in said inspection fund. Said board shall be authorized to employ special brand inspectors when and where needed for special inspection, and which said special inspectors shall be paid such proportion of fees collected by virtue of such inspection as the board may allow. Inspectors may be required to enter into a bond in the sum of twenty-five hundred dollars (\$2,500), conditional as provided by section four of this act.

Appointment of veterinary surgeon; duties, salary, etc.

SEC. 8. It shall be the duty of the board of stock inspection, at its first meeting, to appoint a competent veterinary surgeon as State veterinary surgeon. Before entering upon the duties of his office the said

veterinary surgeon shall give a bond in the sum of ten thousand dollars (\$10,000) for the faithful performance of his duties, with good and sufficient sureties, as conditioned in section four of this act, which said bond shall be filed with the secretary of state. It shall be the duty of the State veterinary surgeon to investigate any or all cases of contagious diseases or infectious diseases among the domestic animals of this State which may come to his knowledge, and for that purpose he shall visit at once any locality within the State where any such disease may be reported to exist, and shall make full and careful examination of all or any animals in that locality. He shall prescribe the proper care and necessary remedies, inaugurate and direct the necessary sanitary measures to prevent the spread of such disease, and report the same to the State board of stock inspection commissioners. He shall perform any other and further duties as may be prescribed by law or by rule of the State board of stock-inspection commissioners. The State veterinary surgeon shall be paid an annual salary of fifteen hundred dollars (\$1,500), and he shall be allowed not to exceed five hundred dollars (\$500) per year for the payment of expenses necessarily incurred, as evidenced by vouchers, in traveling through the State in performance of his official duties, to be paid monthly out of the State treasury, upon warrants drawn by the State auditor upon the stock inspection fund.

Board may dismiss employees.

Sec. 9. All officers and appointees of the State board of stock-inspection commissioners shall hold office only during the pleasure of said board, and may be removed by the said board at any time.

Regulations for quarantine, importations, etc. Fees.

Sec. 10. The State board of stock-inspection commissioners may make and adopt such quarantine and sanitary regulations affecting the movement of live stock into and out of the State of Colorado, and within the borders of said State, as may from time to time be necessary to prevent the introduction into the State, or the spread within the State, of any contagious or infectious disease, and the expenses of such quarantine measures, and the carrying out of such regulations shall be made by the imposition of a fee of three cents per head on all cattle and horses, and one and one-half cents per head on all sheep entering the State of Colorado from any quarantined or infected territory, and whenever the State board of stock-inspection commissioners shall know, or have good reason to believe, that any contagious or infectious disease exists in any locality in any other State, Territory, or country, or that there are conditions which render domestic animals from such infected districts liable to bring such disease into this State, they may report the same to the governor of the State of Colorado, whereupon he shall, by proclamation, prohibit the importation of any such live stock into this State, unless accompanied by certificate of health given by the veterinary surgeon or sanitary inspectors appointed by the State board of stock-inspection commissioners, which surgeon or sanitary inspector shall carefully examine all such live stock previous to the giving of such certificate. All fees connected with such examinations are to be paid by the owner or owners of such stock so examined: *Provided*, That no sanitary inspection shall be necessary and no fees collected from the owners of any animals to which a clean bill of health has been previously granted by the Federal authorities within ten days from the day they have entered the State, or such other further time as the board may determine in its rules and regulations, and that no fee shall be collected from the owner of any animals entering this State by railroad in direct route to other States or Territories, and which do not remain in the State of Colorado for a longer period than is required for watering, unloading, or feeding in transit.

County sheep inspectors; duties, salary, etc.

Sec. 11. The State board of stock-inspection commissioners shall, upon the request and recommendation of ten wool growers, residents of any county in the State, appoint some practical sheep man inspector of said county. Said inspector's duty shall be to prevent and suppress any infectious or contagious diseases among sheep, under such regulations as may be prescribed by the board. Said sheep inspector shall be paid three dollars (\$3) per day for the actual time employed, and his actual traveling expenses, not to exceed three hundred dollars (\$300) in any one year, to be paid out of the stock-inspection fund upon his sworn voucher, to be approved by the county commissioners of said county.

Powers of board to prevent spread of disease.

Sec. 12. It shall be the duty of the State board of stock-inspection commissioners to make and adopt such quarantine and sanitary regulations as are deemed necessary to prevent the introduction of southern or splenic fever, contagious pleuro-pneumonia, or any other contagious or infectious disease, under such regulations as shall not conflict with this act, and it shall have power to order the

destruction of stock to prevent the spread of disease or to crush out such disease, when deemed necessary by the board for the public safety.

Board may order stock destroyed. SEC. 13. The said board of stock-inspection commissioners may condemn diseased stock and cause the same to be killed, for which no compensation shall be paid.

Penalty for violating regulations. SEC. 14. Any person or corporation who shall violate or disregard any brand, quarantine or sanitary provision of this act, or any brand, sanitary or quarantine rule, regulation, or order of the board, made in pursuance of its official duties, shall be guilty of a misdemeanor and upon conviction thereof shall be fined in the sum of not more than five hundred dollars (\$500) or imprisonment in the county jail for a period not to exceed one year, or by both such fine and imprisonment.

Board may secure evidence on oath. SEC. 15. For the purpose of this act each member of the State board of stock-inspection commissioners, the secretary of said board, and the State veterinary surgeon is authorized to administer oaths for the purpose of eliciting information to be used in the furtherance of quarantine and sanitary regulations.

Brand-inspection fees. SEC. 16. In addition to the funds now provided by law for the purpose of providing the State board of stock-inspection commissioners with sufficient funds wherewith to meet and defray its expenses, it is hereby made the duty of the brand inspectors appointed by said board to charge and collect a fee of not to exceed three cents (3c.) per head, as a brand-inspection tax, on all cattle, horses, and mules to be shipped by rail from any point in this State to any point without this State, or to be driven out of the State, said fee to be determined by said board of stock-inspection commissioners, and to be collected by said brand inspectors from the owners or persons in charge of said cattle, horses, or mules, before issuing any certificate of brand inspection granting leave to the owners or persons in charge of said cattle, horses, or mules, to load the same into railroad cars for shipment from any point within this State to any point without this State, or to drive the same beyond the boundaries of this State, and the fee so collected shall be reported and transmitted to the State board of stock-inspection commissioners at such time and in such manner as it shall by regulation require: *Provided*, That in no case shall said fees exceed one dollar (\$1) for any carload of cattle, horses, or mules so shipped or driven: *Provided further*, That no fee shall be charged for an inspection made where stock is shipped from one point to another within the State.

Animals going out of State must first be inspected. SEC. 17. It shall be the duty of every person or persons, firm, association, or corporation shipping cattle, horses, or mules from any point within this State to any point within or without this State, or intending to drive same beyond the boundaries of this State, to hold the same at some convenient place for inspection, as hereinafter provided by this act. And it shall be unlawful for any person or persons, firm, association, or corporation to ship any cattle, horses, or mules upon any railroad in this State, or to drive the same beyond the boundaries of this State until the same shall have been duly inspected as hereinafter provided.

Unlawful for railroads to ship animals without inspection certificate. SEC. 18. It shall be unlawful for any railroad company to receive for transportation any herd, band, or carload of cattle, horses, or mules, until the same shall have been duly inspected as hereinafter required by this act, and until such railroad company shall have been furnished with a certificate by a duly authorized brand inspector, showing that the brands or earmarks upon such cattle, horses, or mules have been duly inspected as required by this act; and any railroad company, or any officer, agent, or servant, of any railroad company, who shall violate the provisions of this section, shall be guilty of a misdemeanor, and upon conviction shall be fined not more than five thousand dollars (\$5,000).

Method of inspection before leaving State. SEC. 19. Every person or persons, firm, association or corporation, or their or either of their agents, servants, or employees, having in charge cattle, horses, or mules destined for transportation by rail from any point within this State to any point within or without this State, or to be driven beyond the boundaries of this State, shall make application to the State board of stock inspection commissioners, or some duly authorized inspector of said board, to inspect the brand or brands and earmarks of any such cattle, horses, or mules, stating in such application the time and place, when and where said animals will be ready for inspection, and it shall be the

duty of such inspector, or some other inspector, to be designated by the said board, within twenty-four hours after the reception of such notice, to attend at the place designated in such application, and inspect said cattle, horses, or mules, make the necessary record and give the necessary certificate required by the provisions of this act. In all cases of cattle, horses, or mules transported by rail, the place of inspection shall be at some stock yard, at the proposed point of shipment of said animals, and cattle, horses, or mules destined to be driven out of the State shall be held at some point within ten miles of the State line for inspection before being driven from the State, and if the owner or person in charge of said animals shall cause any unreasonable delay or loss of time to such inspector so notified to attend, such owner or person in charge of any such cattle, horses, or mules shall pay the expenses and salary of such brand inspector during such delay or loss of time, not to exceed five dollars (\$5) per day.

Penalty for shipping or substituting animals not inspected.

animals other than those described in the certificate provided by the brand inspector inspecting such animals, as provided in section nineteen of this act, or should they remove any of said animals and substitute others therefor, without the knowledge of said inspector, they shall be guilty of a misdemeanor, and upon conviction shall be fined not more than one thousand dollars (\$1,000) or imprisonment not more than one year or by both such fine and imprisonment, as the court may determine.

SEC. 20. Should any person, persons, firm, association, or corporation, or their or either of their agents or employees, ship any

Inspectors must issue certificates and report all inspections.

the board of stock inspection commissioners, to inspect the brands and earmarks of any cattle, horses, or mules to be transported by rail from any point within this State to any point within or without the State, or to be driven out of the State, to make a report to the secretary of the State board of stock inspection commissioners, which he shall certify to as correct, of the result of such inspection at least once every thirty days, or oftener if in the opinion of the secretary of said board of stock inspection commissioners it shall be necessary so to do. It shall also be the duty of said brand inspector to furnish to any person, firm, association, or corporation, or their or either of their agents, servants, or employees, having cattle, horses, or mules destined to be so shipped or driven, with a certificate to the effect that they have duly inspected the brands and earmarks of any such cattle, horses, or mules enumerated and designated in the notice furnished such brand inspector as herein provided for.

SEC. 21. It shall be the duty of the brand inspector who shall be notified as hereinbefore provided, or who shall be selected by

Penalty for issuing false certificate.

SEC. 22. Any inspector who shall knowingly make any false certificate under the provisions of this act to the secretary of the State board of stock inspection commissioners, shall upon conviction thereof be guilty of a misdemeanor and be fined in a sum not exceeding one thousand dollars (\$1,000) or imprisonment not exceeding one year, or both such fine and imprisonment, at the discretion of the court.

Penalty for illegal shipping or driving of animals.

SEC. 23. Any person, persons, firm, association, or corporation, who shall violate any of the provisions of this act, or who shall ship any band, herd, or carload of cattle, horses, or mules upon any railroad in this State, or who shall drive the same beyond the boundaries of this State, without having had the same inspected as required by the provisions of this act, shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be fined in a sum not more than one thousand dollars (\$1,000) or by imprisonment for a period of not more than one year, or both such fine and imprisonment, but nothing in this act shall be construed as repealing the laws now in force respecting the larceny of live cattle or stock.

Inspectors shall hold animals not belonging to shippers.

SEC. 24. In making any inspection of any animals as provided in this act, prior to shipment by rail or removal from the State, if any inspector shall find any animal or animals bearing marks and brands other than those of the owner of the other cattle in said shipment, and if said owner or shipper shall fail to exhibit a bill of sale or other authority for the possession of said animal or animals in said shipment, the inspector shall forthwith declare them to be estrays, and shall take possession of the same for the State board of stock inspection commissioners, and dispose of the same according to the rules and regulations prescribed by said board.

Board to make disposition of animals held.

SEC. 25. The State board of stock inspection commissioners are hereby authorized and empowered to make such reasonable rules and regulations regarding the disposition of estrays taken up by inspectors, as provided in section twenty-four of

this act, as may seem to said board to be proper and just and for the best interests of the owners of same.

Disposition of funds received by board. SEC. 26. All moneys coming into the hands of the secretary of the State board of stock inspection commissioners from the sale of estray animals shall constitute and be known as the "estrays" fund, and shall be kept in an account separate and distinct from other accounts, in conformity with regulations to be prescribed by said board. All other funds of said board, including fees collected for the inspection of cattle, shall constitute and be known as the "brand inspection" fund of said board, which shall be kept in conformity with the regulations to be prescribed by said board.

Reimbursing owners of estray animals sold. SEC. 27. Any person, persons, association, or corporation, establishing to the satisfaction of the said stock inspection board the ownership to any estray animals which have been sold by said board, and the amount realized from such sale deposited in the estray fund, as herein provided, shall be forthwith paid the amount for which said animal or animals were sold, less the sum of one dollar (\$1) for each animal, which shall be retained by the said board and placed in the brand-inspection fund.

Final disposition of estray funds. No claims allowed after three years. SEC. 28. Any and all moneys now in the estray fund, derived from the sale of estray animals by the State board of stock inspection commissioners, or any inspector acting under the authority of said board, which has been in the possession of said board of stock inspection commissioners for six years or longer from the date of sale of such estray animal or animals, and for which no valid claim has been made, shall be turned into the brand-inspection fund of said board, and all claims for moneys from the estray fund made by the owners of cattle sold as estrays by said board, after the passage of this act, shall be made within three years from the date of sale of the same, or the same shall be forever barred and no moneys shall be paid upon claims made after three years from the date of such sale. The funds so transferred from the estray fund may be used by the said board under proper vouchers for the prosecution of persons charged with larceny of live stock, and for other and general expenses of the board.

Office regulations of board. SEC. 29. The State board of inspection commissioners shall occupy quarters in the capitol building of the State of Colorado, which shall be their general office, and which shall be kept open from nine o'clock, a. m., to five o'clock, p. m., daily, Sundays and legal holidays excepted.

Penalty for violation of this act. SEC. 30. Any person, firm, association, or corporation, or their or either of their agents or employees, who shall violate any of the provisions of this act, shall be punished by a fine not exceeding one hundred dollars (\$100) to be paid into the school fund of the county in which the conviction is secured, or by imprisonment not exceeding six months, or by both such fine and imprisonment, at the discretion of the court.

Acts and parts of acts repealed. SEC. 31. An act entitled "An act to prevent and suppress infectious and contagious diseases among the domestic animals of this State, and for the appointment of the necessary officers to carry into effect the same, and to fix compensation," approved March 23, 1885, and as amended April 8, 1893, and an act entitled "An act to prevent the introduction of any infectious or contagious disease among the cattle and horses of this State," approved March 21, 1885, and sections 19 and 20 of an act entitled "An act to amend an act entitled 'An act to provide for the branding, herding, and care of stock, and to repeal certain acts in relation thereto,'" approved February 18, 1881, and as amended April 2, 1885, and an act entitled "An act in relation to live stock and to provide for the inspection of same before shipment or removal beyond the boundaries of this State, and to provide penalties for the violation of this act, and to repeal all acts inconsistent therewith," approved April 14, 1899; all of the same being in conflict with this act, and all other acts and parts of acts inconsistent with the provisions of this act are hereby repealed.

Emergency clause. SEC. 32. In the opinion of the general assembly an emergency exists, therefore this act shall take effect and be in force from and after May 1, 1903.

Approved April 6, 1903.

FLORIDA.

AN ACT To provide for the investigation of diseases among domestic animals, and to prevent the spread of contagious diseases among such.

Be it enacted by the Legislature of the State of Florida:

General powers vested in board of trustees of University of Florida. SECTION 1. The board of trustees of the University of Florida is hereby authorized and empowered to investigate diseases among domestic animals, to prescribe rules and regulations for such investigations, and to adopt such measures as will prevent the spread of contagious diseases among such. Said board is hereby authorized to employ an agent, to be known as "veterinarian," who shall be a graduate of a veterinary college, and have had at least five years' experience in the practice of veterinary medicine, and who has made original investigations in veterinary science, to require of such veterinarian such duties as in the judgment of the said board will promote the welfare of the domestic animals of the State of Florida, and to aid in the discrimination [dissemination] of knowledge of veterinary science.

Board may issue quarantine regulations. SEC. 2. The said board of trustees shall have the same power to promulgate rules and regulations and to enforce the same concerning segregation and quarantine of domestic animals when they have reason to believe they are infected with any contagious disease or in any danger of conveying it to other animals as is now by law conferred upon the State health officers concerning persons. The duties and powers of the said board of trustees and said veterinarian shall be regulated and controlled by the laws regulating the powers and duties of the State board of health and State health officers, in so far as such rules and regulations may be applicable to the duties herein imposed.

SEC. 3. This act shall take effect upon its approval by the governor.

Approved June 3, 1903.

GEORGIA.

AN ACT To make penal the importation of any stock with contagious diseases, excepting distemper, inside the limits of this State, to prescribe penalties for same, and for other purposes.

Be it enacted by the General Assembly of Georgia:

Unlawful to import diseased stock. SECTION 1. That from and after the passage of this act it shall be unlawful for any person to knowingly import within the limits of this State any stock with contagious diseases, except distemper.

Penalty. SEC. 2. *Be it further enacted,* That any person violating provisions of this act shall be guilty of misdemeanor, and shall be punished as now prescribed in the code of Georgia for offenses of like character.

Repealing clause. SEC. 3. *Be it further enacted,* That all laws and parts of laws in conflict herewith be, and the same are, hereby repealed.

Approved November 5, 1901.^a

IDAHO.

AN ACT To amend sections 16 and 17 of an act entitled "An act to suppress contagious and infectious diseases of sheep; to create the office of sheep inspector and deputy State sheep inspectors, to provide for the appointment of the same and to fix their compensation; making the doing of certain acts a crime and providing for the punishment of the same, and for other purposes," and repealing an act entitled "An act to suppress contagious and infectious diseases of sheep, to create the office of State sheep inspector and of deputy sheep inspectors, to provide for the appointment of the same and fix their compensation; making the doing of certain acts a crime, and providing for the punishment of the same, and for other purposes," approved February 25, 1899, approved March 7, 1901.

Be it enacted by the Legislature of the State of Idaho:

Law of 1901 amended. SECTION 1. That section 16 of an act entitled "An act to suppress contagious and infectious diseases of sheep, to create the office of sheep inspector and deputy State sheep inspectors, to provide for the appointment of the same and to fix their compensation; making the doing of certain acts a crime, and providing for the punishment of the same, and for other

^aThe last publication of laws, containing those of 1900-1901, did not include this law, because the legislature of Georgia does not meet until October in each year, and therefore it was not published in time.

purposes;" and repealing an act entitled "An act to suppress contagious and infectious diseases of sheep, to create the office of State sheep inspector and of deputy sheep inspectors, to provide for the appointment of the same and fix their compensation; making the doing of certain acts a crime, and providing for the punishment of the same, and for other purposes," approved February 25, 1899, approved March 7, 1901, be amended to read as follows: Section

Regulations for bringing sheep into State.

16. Any person, persons, company, corporation or association, or any agent or employee of any person, persons, company, corporation or association, intending to bring or cause to be brought from any other State or Territory any sheep into the State of Idaho in any manner, except by shipping the same through the State by railroad train, whether any proclamation shall have been issued by the governor or not, shall, before crossing the State line, notify the deputy sheep inspector of the county or district into which the said sheep are intended to be brought. Which notice shall set forth number of sheep, the brands thereon and name of the owner or owners thereof and the particular locality from which said sheep have come and through which they have been driven. The deputy sheep inspector, under such regulations as have or may be provided by law and the State sheep inspector, shall thereupon make such investigation and inspection as he may deem necessary, and shall make written report of such investigation and inspection to the State sheep inspector, who shall thereupon make an order in writing, signed by him, which order shall either permit said sheep to enter the State of Idaho or shall provide that the same shall be held under the control of such deputy inspector at the State line, for such period of time as the said State sheep inspector shall deem necessary, which period shall be specified and set forth in such order. If at the end of the period so specified in such order it shall appear that said sheep are free from disease and can safely be brought into the State, the State sheep inspector shall make an order in writing, signed by him, permitting the said sheep to be brought into the State; and thereupon the said sheep shall become in all respects subject to the sheep inspection and quarantine laws of this State. Any sheep in transit through this State upon any railroad train shall not be unloaded from such train for any purpose, except at such points as shall be designated by the State sheep inspector, and when so unloaded at such points shall be held in the feed yards at such point and shall not be allowed to leave the same except to be reloaded upon said train for transit through or out of the State. All expenses of enforcing the provisions of this section shall be paid by the owner or owners of the sheep. Any person who shall violate any of the provisions of this section shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be punished by imprisonment in a county jail not more than sixty days or by a fine of not less than five hundred dollars (\$500) nor more than five thousand dollars (\$5,000), which fine shall be a lien upon said sheep and may be enforced by proper proceedings in any court of competent jurisdiction.

Seizure of sheep illegally brought into State.

SEC. 2. That section 17 of said act be amended to read as follows: Section 17. When sheep are brought into this State from another State in violation of any of the provisions of this act, it shall be the duty of the deputy sheep inspector of the district or county wherein said sheep may be, immediately to seize the same and hold them in his possession, and to file a complaint in a court of competent jurisdiction, charging the owner or person in charge of said sheep with such violation, and, upon conviction of the defendant or defendants so offending, the said deputy shall (unless all fines, costs, and charges be immediately paid) sell, in the same manner as sales of personal property on execution out of the district court are made, so many of said sheep as may be necessary to pay the costs and charges of making such sale, including the compensation due him, together with the fine imposed upon such conviction, and a certified copy of the judgment of conviction shall be sufficient warrant for making such sale.

Approved February 17, 1903.

AN ACT To amend section 1 of an act entitled "An act establishing quarantine against diseased sheep, prescribing the duties of the governor and State sheep inspector in relation thereto, and providing penalties for the infraction of its provisions," approved March 1, 1901, prescribing duty of owners or persons in charge of prohibited sheep and prescribing penalties, and repealing an act entitled "An act establishing quarantine against diseased sheep, prescribing the duties of governor in relation thereto, and providing penalties for the infraction of its provisions," approved March 13, 1899.

Be it enacted by the Legislature of the State of Idaho:

Law of 1901 amended.

SECTION 1. That section 1 of an act entitled "An act establishing quarantine against diseased sheep, prescribing the duties of the governor and State sheep inspector in relation thereto, and providing

penalties for the infraction of its provisions," approved March 1, 1901, be amended
Governor may proclaim quarantine against diseased localities. to read as follows: Section 1. Whenever the governor of the State has reason to believe that scab or any other infectious

disease has become epidemic in a certain locality or localities in any other State or Territory, or that conditions exist that render sheep likely to convey disease, or whenever the State sheep inspector shall certify in writing to the governor that conditions exist in certain localities in any other State or Territory that render sheep coming therefrom likely to convey disease, the governor shall forthwith, by proclamation, designate and schedule such locality or localities and prohibit the importation from it or them of any sheep into this State, except under such restrictions as he may deem proper.

Any person or persons or corporation who, after publication of such proclamation, has or receives in charge any such sheep from any of the prohibited districts and transports, conveys or drives the same to and within the limits of any of the counties of this State is punishable by fine not exceeding five thousand dollars (\$5,000) nor less than two hundred dollars (\$200) and is liable for all damages that may be sustained by any person by reason of the importation or transportation of such prohibited sheep: *Provided, however,* That nothing herein contained shall prohibit the transportation of sheep from such district through the State by railroad train under such restrictions and regulations as may be prescribed by law or by the governor or the State sheep inspector, or either of them.

Repealing clause. SEC. 2. That an act entitled "An act establishing a quarantine against diseased sheep, prescribing the duties of governor in relation thereto, and providing penalties for the infraction of its provisions," approved March 13, 1899, and all other acts and parts of acts in conflict herewith, are hereby repealed.

SEC. 3. Whereas an emergency exists, this act shall be in force from and after its passage.

Approved February 17, 1903.

AN ACT To amend section 2 of an act entitled "An act to suppress contagious and infectious diseases of sheep; to create the office of sheep inspector, and deputy State sheep inspectors; to provide for the appointment of the same and to fix their compensation; making the doing of certain acts a crime, and providing for the punishment of the same, and for other purposes, and repealing an act entitled "An act to suppress contagious and infectious diseases of sheep; to create the office of State sheep inspector and of deputy sheep inspectors; to provide for the appointment of the same and fix their compensation; making the doing of certain acts a crime and providing for the punishment of the same, and for other purposes," approved February 25, 1899, approved March 7, 1901.

Be it enacted by the Legislature of the State of Idaho:

SECTION 1. That section 2 of an act entitled "An act to suppress contagious and infectious diseases of sheep; to create the office of sheep inspector, and deputy State sheep inspectors; to provide for the appointment of the same and to fix their compensation; making the doing of certain acts a crime and providing for the punishment of the same and for other purposes, and repealing an act entitled "An act to suppress contagious and infectious diseases of sheep; to create the office of State sheep inspector and deputy sheep inspectors, to provide for the appointment of the same and fix their compensation; making the doing of certain acts a crime and providing for the punishment of the same, and for other purposes," approved February 25, 1899, approved

Sheep inspector, salary and duties. March 7, 1901, be and the same is hereby amended to read as follows: Sec. 2. The said sheep inspector shall receive as full compensation for his services a salary of twelve hundred dollars (\$1,200) per annum and ten cents (10c.) a mile for each mile actually traveled in the discharge of his official duties: *Provided,* The total amount of such mileage shall not exceed the sum of one thousand dollars (\$1,000) for any one year, such compensation to be paid as the salary and fees of other State officers are paid: *And provided further,* That no mileage shall be allowed, to be paid out of the State treasury, to said inspector in cases wherein payment of his expenses is otherwise provided for in this act. It shall be the duty of the State sheep inspector to have general supervision over his deputies appointed under the provisions of this act, and to aid, counsel, and advise with such deputies, and generally to enforce the provisions of this act. The said sheep inspector shall have the same power within the entire State as the deputies appointed by him have in their respective districts, and where the services of the State sheep inspector are demanded in a county or district other than that in which he resides, to settle differences between sheepmen and any deputy, it shall be the duty of said State sheep inspector to go and adjust such differ-

ences, and the said party or parties demanding such services shall pay the actual traveling expenses of said State sheep inspector.

SEC. 3 [2]. Whereas an emergency exists, this act shall be in force from and after its passage.

Approved March 6, 1903.

AN ACT To prevent the importation, selling, or running at large of domestic animal or animals with any infectious or contagious disease.

Be it enacted by the Legislature of the State of Idaho:

Penalty for importing diseased animals. SECTION 1. It shall not be lawful for the owner of any domestic animal or animals, or any person having them in charge, knowingly to import or drive into the State any animal or animals having any contagious or infectious disease; and any person so offending shall be deemed guilty of a misdemeanor, and shall be punished by a fine in any sum not less than ten dollars (\$10) nor more than one hundred dollars (\$100) and [or] be imprisoned in the county jail not more than three months, or both, in the discretion of the court.

Penalty for disposing of diseased animals. SEC. 2. Any person, being the owner of any domestic animal or animals, or having the same in charge, who shall suffer any such domestic animal or animals having any contagious or infectious disease, knowing the same to be so diseased, to run at large upon any range, common, or highway, or shall let the same approach within ten rods of any highway, or shall sell or dispose of any domestic animal or animals, knowing the same to be so diseased, without fully disclosing the fact to the purchaser, shall be deemed guilty of a misdemeanor, and shall be punished by a fine in any sum not exceeding five hundred dollars (\$500) and imprisoned in the county jail not less than six months.

Recovery of damages by civil action. SEC. 3. Nothing in this act shall be construed as to prevent the recovery of damages in a civil action against any person or persons who shall sell, trade, or import, or drive into this State, such diseased animal or animals, or who shall allow such domestic animal or animals to run at large, or to approach nearer than ten rods of any highway.

Powers of justice of peace. SEC. 4. Any justice of the peace, upon proof before him that any animal or animals are going at large or driven in or through his county in violation of the preceding sections, shall order a constable or sheriff to impound them, and the owner thereof shall be held liable for all costs and damages; in case owner is not known, said justice of the peace shall thereupon summon three disinterested citizens who shall be stock owners of the neighborhood to examine said animal or animals, said examiners, before entering upon the discharge of their duties, shall be sworn to make a true and faithful report without prejudice or favor. They shall, after making examination, return certified copies of the nature of the diseased animal or animals, together with an accurate description of each animal or animals, giving all brands, earmarks, wattles, age, sex, and class, to the justice of the peace by whom they were summoned, who shall, after entering the same upon his records, have [the same] published in some newspaper in the county for one week, where said animal or animals are impounded. If the owner does not claim said animal or animals and pay all costs and damages within ten days after impounding, said justice of the peace shall order constable or sheriff to slaughter such animal or animals and destroy the carcass by burning to ashes.

When any diseased animal or animals are impounded by the constable or sheriff, the fees shall not be more than twenty-five cents (25c.) per head for the first ten head, and ten cents (10c.) per head for all additional animals impounded, the feeding and watering of such animal or animals shall be ordered by the constable or sheriff and shall not exceed fifteen cents (15c.) per day for each animal, all charges for impounding, examining, feeding, slaughtering, and burning shall be paid by the county in which said animal or animals were impounded, out of the general county fund.

Additional liability for damages. SEC. 5. Any person violating any of the provisions of this act, in addition to the penalties herein provided, shall be liable for all damages that may accrue to the party damaged by reason of said diseased animal or animals imparting disease.

SEC. 6. Whereas an emergency exists, this act shall take effect and be in force from and after its passage and approval.

Approved March 10, 1903.

MASSACHUSETTS.

AN ACT Making an appropriation for the compensation of inspectors of animals.

Be it enacted, etc., as follows:

\$7,000 appropriated for inspectors. SECTION 1. A sum not exceeding seven thousand dollars (\$7,000) is hereby appropriated, to be paid out of the treasury of the Commonwealth, from the ordinary revenue, for the compensation of inspectors of animals, during the year ending on the thirty-first day of December, nineteen hundred and two.

SEC. 2. This act shall take effect upon its passage.

Approved January 31, 1902.

AN ACT To abolish the board of cattle commissioners and to create a cattle bureau of the State board of agriculture.

Be it enacted, etc., as follows:

Board of cattle commissioners abolished. SECTION 1. The board of cattle commissioners is hereby abolished.

Cattle bureau created. SEC. 2. A bureau of the State board of agriculture is hereby created, to be known as the cattle bureau of the State board of agriculture.

Chief of cattle bureau, duties and salary. SEC. 3. The governor shall annually appoint a chief of the cattle bureau of the State board of agriculture, who shall have the powers and perform the duties heretofore conferred and imposed upon the board of cattle commissioners: *Provided*, That no orders or regulations made by him under authority of sections four and seven of chapter ninety of the Revised Laws shall take effect until approved by the governor and council. His appointment shall be confirmed by the executive council. He shall make a written report on or before the tenth days of January and July in each year to the State board of agriculture, and the board shall include an abstract of his reports in its annual report to the general court. He shall receive an annual salary of eighteen hundred dollars (\$1,800) and the amount of his necessary expenses, and may appoint a clerk at a salary of twelve hundred dollars (\$1,200) a year.

Sec. 1, chap. 89, Rev. Laws, amended. SEC. 4. Section one of chapter eighty-nine of the Revised Laws is hereby amended by inserting after the word "agriculture," in the third line, the words "the chief of the cattle bureau of the State board of agriculture," so as to read as follows: Section 1. The governor and lieutenant governor, ex officio, the secretary of the Commonwealth, the president of the agricultural college, the secretary of the State board of agriculture, the chief of the cattle bureau of the State board of agriculture, one person appointed from and by the Massachusetts Society for Promoting Agriculture, one person appointed from and by each agricultural society which receives an annual bounty from the Commonwealth, and three other persons appointed by the governor, with the advice and consent of the council, shall constitute the State board of agriculture.

SEC. 5. So much of section three of this act as authorizes the appointment of said chief of the cattle bureau shall take effect thirty days after the passage of this act, and the remainder of the act shall take effect as soon as the said chief has been appointed and qualified.

Approved February 25, 1902.

AN ACT Making an appropriation for expenses of the board of cattle commissioners.

Be it enacted, etc., as follows:

\$8,000 appropriated for exterminating animal diseases. SECTION 1. The sum of eight thousand dollars (\$8,000) is hereby appropriated, to be paid out of the treasury of the Commonwealth

for the ordinary revenue, to meet expenses authorized by the board of cattle commissioners in connection with the extermination of contagious diseases among horses, cattle, and other animals, from January first to April fifteenth of the present year.

SEC. 2. This act shall take effect upon its passage.

Approved March 26, 1902.

AN ACT Making an appropriation for exterminating contagious diseases among horses, cattle, and other animals.

Be it enacted, etc., as follows:

\$50,000 appropriated for exterminating animal diseases.

SECTION 1. The sum of fifty thousand dollars (\$50,000) is hereby appropriated, to be paid out of the treasury of the Commonwealth from the ordinary revenue, for the extermination of contagious diseases among horses, cattle, and other animals, during the year ending on the thirty-first day of December, nineteen hundred and two.

SEC. 2. This act shall take effect upon its passage.

Approved April 11, 1902.

AN ACT Relative to the inspection of certain domestic animals, and of certain carcasses.

Be it enacted, etc., as follows:

Secs. 103 and 104, chap. 75, Rev. Laws, repealed.

SECTION 1. Sections one hundred and three and one hundred and four of chapter seventy-five of the Revised Laws are hereby repealed.

Sec. 105, chap. 75, Rev. Laws, amended.

SEC. 2. Section one hundred and five of chapter seventy-five of the Revised Laws is hereby amended by striking out the word "six," in the first line, and inserting in place thereof the word "four," so as to read as follows: Section 105. The provisions of the four preceding sections shall not apply to a person not engaged in such business, who, upon his own premises and not in a slaughterhouse, slaughters his own neat cattle, sheep, or swine, but the carcass of any such animals shall be inspected by an inspector at the time of slaughter, unless said animal is less than six months old or has been duly inspected, under the provisions of chapter ninety, within six months prior to such slaughter and a certificate of health has been delivered to the owner or person in charge thereof.

SEC. 3. This act shall take effect upon its passage.

Approved April 17, 1902.

AN ACT Making an appropriation for the compensation of inspectors of animals.

Be it enacted, etc., as follows:

\$7,000 appropriated for inspectors.

SECTION 1. A sum not exceeding seven thousand dollars (\$7,000) is hereby appropriated, to be paid out of the treasury of the Commonwealth from the ordinary revenue, for the compensation of inspectors of animals during the year ending on the thirty-first day of December, nineteen hundred and three.

SEC. 2. This act shall take effect upon its passage.

Approved January 31, 1903.

AN ACT Making an appropriation for exterminating contagious diseases among horses, cattle, and other animals.

Be it enacted, etc., as follows:

\$58,000 appropriated for exterminating animal diseases.

SECTION 1. The sum of fifty-eight thousand dollars (\$58,000) is hereby appropriated, to be paid out of the treasury of the Commonwealth from the ordinary revenue, for the extermination of contagious diseases among horses, cattle, and other animals during the year ending on the thirty-first day of December, nineteen hundred and three.

SEC. 2. This act shall take effect upon its passage.

Approved February 13, 1903.

AN ACT Relative to the marking of certain carcasses, and the inspection of certain domestic animals.

Be it enacted, etc., as follows:

Chap. 75, of Rev. Laws, added to.

SECTION 1. Chapter seventy-five of the Revised Laws is hereby amended by inserting after section one hundred and two the following new sections: Section 103. In a slaughtering establishment wherein inspection and branding is not carried on under the rules

and regulations for the inspection of live stock and other products, established by the United States Department of Agriculture in accordance with acts of Congress in

force on the fifteenth day of June in the year nineteen hundred and one, the carcasses of animals slaughtered under the provisions of the four preceding sections shall at the time of slaughter, if not condemned, be stamped or branded by the inspector thereof in like manner as those inspected by the United States Bureau of Animal Industry for interstate trade, by a stamp or brand designed for the purpose by the cattle bureau of the State board of agriculture, which shall be furnished by it to the board of health of a city or town applying therefor. Such stamps shall be uniform in design throughout the Commonwealth, but shall contain the name of the city or town in which they are used. Section 104. The carcasses of animals slaughtered under the provisions of the five preceding sections, and not stamped or branded as provided in the preceding section, shall be deemed unfit for human food and shall not be sold or offered for sale. Whoever sells, or offers for sale, or has in his possession with intent to sell, a carcass or any part thereof required by the provisions of the preceding section to be stamped or branded, which has not been stamped or branded as therein provided, shall be punished by a fine of not more than one hundred dollars (\$100) or by imprisonment for not more than sixty days, or by both such fine and imprisonment.

Penalty for selling unstamped carcasses.

Sec. 2, chap. 312, acts of 1902, amended.

Sec. 2. Section one hundred and five of said chapter seventy-five, as amended by section two of chapter three hundred and twelve of the acts of the year nineteen hundred and two, is hereby further amended by striking out the word "four," in the second line, and inserting in place thereof the word "six," so as to read as follows: Section 105. The provisions of the six preceding sections shall not apply to a person not engaged in such business, who, upon his own premises and not in a slaughterhouse, slaughters his own neat cattle, sheep, or swine, but the carcass of any such animals shall be inspected by an inspector at the time of slaughter, unless said animal is less than six months old or has been duly inspected, under the provisions of chapter ninety, within six months prior to such slaughter, and a certificate of health has been delivered to the owner or person in charge thereof.

Approved April 9, 1903.

RESOLVE To provide for compensating owners of animals killed in exterminating the foot-and-mouth disease.

\$40,000 appropriated for foot-and-mouth disease.

bureau of the State board of agriculture, to the owners of animals in this Commonwealth that were slaughtered previous to April eleven, in the current year, by order of the State authority, for the purpose of exterminating the disease known as the foot-and-mouth disease, in addition to the amount paid by the United States, a sum equal to the difference between the amount already paid and the value of such cattle, as appraised by the agents of the United States. For this purpose there may be expended from the treasury of the Commonwealth a sum not exceeding forty thousand dollars (\$40,000).

Approved May 26, 1903.

RESOLVED, That there be allowed and paid out of the treasury of the Commonwealth, under the direction of the chief of the cattle

MINNESOTA.

AN ACT To amend sections four (4) and twelve [five] (12) [5] of chapter two hundred and thirty-three (233) of the general laws of 1897, as amended by chapter three hundred and twenty-two of the general laws of 1901, entitled "An act to prevent the spread of contagious and infectious diseases among domestic animals in this State."

Be it enacted by the Legislature of the State of Minnesota:

Law of 1897 and 1901 amended. SECTION 1. That section four (4) of chapter two hundred and thirty-three (233) of the general laws of 1897, as amended by chapter three hundred and twenty-two (322) of the general laws of 1901, be and the same is hereby amended so as to read as follows: Section 4. No animal shall be killed by any of the boards of health herein mentioned until it shall first have been adjudged to be infected with a contagious or infectious disease, either by a duly authorized agent of the State board of health or by a competent veterinary surgeon selected by a local health officer or board of health; except, that whenever, in the judgment of the State board

Destruction of diseased and exposed animals.

State board of health or by a competent veterinary surgeon selected by a local health officer or board of health; except, that whenever, in the judgment of the State board

of health, the control or eradication of a disease renders it advisable to do so, such board may order killed and buried, or otherwise destroyed, any domestic animal which has been exposed to a contagious or infectious disease, although at the time not infected therewith: *Provided, however*, That cattle in this State shall not be adjudged infected with the disease of tuberculosis or condemned as being so infected, and that horses in this State shall not be adjudged infected with the disease of glanders or condemned as being so infected, except and until such animal has been inspected by a competent veterinarian under the authority of the State board of health.

Law of 1897 and 1901 amended. SEC. 2. That section five (5) of chapter two hundred and thirty-three (233) of the general laws of 1897, as amended by chapter three hundred and twenty-two (322) of the general laws of 1901, be, and the same is hereby amended so as to read as follows: Section 5.

Destruction of infected animals, post-mortem, appraisement, and compensation to owners.

Whenever a domestic animal has been adjudged to be infected with a contagious or infectious disease and has been ordered killed, the owner or keeper of such animal shall be notified thereof, and within twenty-four (24) hours thereafter he may file a written protest with the board of health which is responsible for such killing against the killing thereof, and shall therein state under oath that to the best of his belief such animal is not infected with any contagious or infectious disease. Whereupon, such animal being killed notwithstanding such report [protest], a postmortem examination thereof shall be made by experts, who shall be present at the killing, and shall be appointed one by the board of health, or its representative, which ordered the killing, one by the owner or keeper, and one by the two already appointed, and if upon such examination said animal shall be found to have been entirely free from contagious or infectious disease they shall also appraise it at its cash value immediately before it was killed, and the amount of such appraisal shall be paid to the person entitled thereto out of the funds of the State or the municipality ordering the killing. The experts shall be paid one-half by the owner or keeper making the protest and one-half by the State or municipality whose board of health is responsible for the killing. In case the owner or keeper of such animal shall fail to appoint, in writing, at the time an expert as herein provided, an expert shall be appointed by the State board of health, or its representative, in lieu of the one provided herein by the owner or keeper. All appraisements and examinations made under this act shall be in writing, signed by the appraisers or examiners, certified to by the board of health ordering the examination or killing, and filed with the treasurer of the State or of the municipality which is responsible for the examination or killing. Upon the filing of any such examinations as appraisal it shall be the duty of the board of health which is responsible for the examination or killing to make a certificate under the hand of its secretary as to the number of days served by and the amount due to said experts or appraisers, and to file the same with the treasurer of the State or municipality, as the case may be, which is responsible for the examination or killing, and upon such filing such treasurer shall pay to each of said experts or appraisers the amount due him, and to the person entitled thereto the amount due him by the terms hereof: *Provided, however*, That any expert or appraiser employed on a salary by the board of health shall receive no compensation hereunder. Whenever any domestic animal has been adjudged infected with the disease of tuberculosis or glanders and has been ordered killed by a duly authorized representative of the State board of health, and is killed in accordance therewith after or without protest, the value of such animal shall be determined by a board of appraisers, consisting of three competent and disinterested men, one to be appointed by the State board of health or its representative, one by the owner or keeper of the condemned animal, within twenty-four (24) hours after the killing is ordered, and the third by the two already appointed, who shall appraise it, before it is killed, at its cash value: *Provided*, That in determining such value the fact that such animal was infected by tuberculosis or glanders shall not be taken into consideration: *And provided further*, That in no case shall the appraised value of a horse afflicted with glanders exceed seventy-five (\$75) dollars, and in no case shall the appraised value of a cow afflicted with tuberculosis exceed thirty-five (\$35) dollars: *And provided*, That payment shall not be made for any such animal unless such animal is one year old or over and has been kept in this State in good faith for at least one year next prior to the killing thereof. In case the owner or keeper fails to appoint an appraiser, as herein provided, one shall be appointed on his behalf by the representative of the State board of health. The market value of the carcass of the tuberculosis animal shall be deducted from the appraised value of the animal, and three-fourths the remainder thereof, or three-fourths of the appraised value of the glandered horse, shall be paid by the State in the manner hereinbefore set forth to the person entitled thereto, who shall bear the

remaining one-fourth of the loss. Each appraiser shall receive one dollar (\$1) a day for his services as appraiser. Whenever any such animal which has been adjudged to be infected is killed by order of said board, but not by the owner or keeper thereof, a postmortem examination thereof shall be made by experts appointed as aforesaid, and if found to have been entirely free from any infectious disease the value of such animal shall be determined and paid for as hereinbefore specified. Except as in this section expressly provided, no compensation shall be paid for any animal killed by virtue of any authority given by this act.

SEC. 3. This act shall take effect and be in force from and after its passage.

Approved April 8, 1903.

AN ACT To establish the State live stock sanitary board of Minnesota and to provide for the suppression and control of dangerous, contagious, and infectious diseases of domestic animals.

Be it enacted by the Legislature of the State of Minnesota:

Composition of State live stock sanitary board.

SECTION 1. That a board is hereby established to be known as "The State live stock sanitary board." This board shall consist of five (5) members to be appointed by the governor of the State of Minnesota. Each member of said board shall be a qualified elector of the State of Minnesota. Three members of said board shall be persons who are financially interested in the breeding and maintenance of live stock in the State of Minnesota, and two members of said board shall be competent and qualified veterinary surgeons who are graduates of some regularly organized and recognized veterinary colleges practicing in the State of Minnesota.

Appointments and terms of members of board.

SEC. 2. In making the first appointments to said State live stock sanitary board the governor shall divide the appointees into five classes: The term of office of each of the first appointees shall commence on the first day of April, 1903; one of said appointees shall hold his office for a term of one year, one for the term of two years, one for the term of three years, one for the term of four years, and one for the term of five years; and at the expiration of the term of office of each of the first appointees a successor shall be appointed, who shall hold his office for a term of five years, so that the term of office of one member of said board shall expire every year. In case of the death, resignation, or removal of any member of said board during his term of office the governor shall appoint a successor to serve the unexpired portion of the term of office of such member.

Meetings of board. Election of officers.

SEC. 3. Immediately after the appointment of the first board hereinafter provided for the members thereof shall meet at the city of St. Paul, and from their own numbers shall elect a president and a vice-president. They shall also elect from outside their numbers a secretary, who shall be a graduate of some regularly organized and recognized veterinary college, who shall be the executive officer of said board, and who shall receive such compensation as said State live stock sanitary board may determine. His term of office shall be one year, and he shall hold his office until his successor is elected and qualified. The said board may also, if it deem expedient, elect a field veterinarian, a bacteriologist, and an attorney for said board, which said officers, if elected, shall also hold office for the term of one year, and shall receive such compensation as may be determined by said State live stock sanitary board. The said State live stock sanitary board shall also have the power to appoint or employ such additional help as it may deem necessary and expedient for carrying into effect the powers and duties conferred on said board by this act.

Members of board to receive expenses, but no salary.

SEC. 4. No member of said State live stock sanitary board shall receive any compensation for any services he may render, either as a member of said board or to said board, under the provisions of this act, save and except that the members of said board shall receive their actual expenses necessarily paid or incurred in the discharge of their duties as members of said board.

Place and dates of meetings of board.

SEC. 5. The said State live stock sanitary board shall hold quarterly meetings in the city of St. Paul on the Friday after the second Tuesday in January, April, July, and October of each year. The annual meeting of said board for the election of officers shall be on the Friday after the second Tuesday in April of each year.

Duties of board.

SEC. 6. It shall be the duty of the said State live stock sanitary board to protect the health of the domestic animals of the State; to determine and employ the most efficient and practical means for the prevention,

suppression, control, and eradication of dangerous, contagious, and infectious diseases among the domestic animals of the State of Minnesota, and for these purposes it is hereby authorized and empowered to make all such rules and regulations for the conduct of the business of said State live stock sanitary board as it may deem expedient.

Local boards of health to cooperate with board.

stock sanitary board in all matters and things pertaining to the prevention, suppression, control, and eradication of dangerous, contagious, or infectious diseases among the domestic animals of the State whenever directed so to do by said State live stock sanitary board or the executive officer thereof, and in such manner as directed by said State live stock sanitary board.

Authority transferred from former board to present one.

any of the domestic animals of this State is hereby taken from said State board of health and conferred upon said State live stock sanitary board. The proviso at the end of section four (4) of chapter two hundred and thirty-three (233) of the laws of Minnesota for the year 1897 is hereby repealed.

General powers of board in prevention of disease.

State to take all steps they may severally deem necessary to control, suppress, and eradicate any and all contagious and infectious diseases among any of the domestic animals in this State, and to that end said boards are hereby severally empowered, within their respective jurisdictions, to quarantine any domestic animal which is infected with any such disease, or which has been exposed to infection therefrom, to kill any animal so infected, and, whenever deemed necessary by the State live stock sanitary board, to kill any animal which has been exposed to the infection of any such disease, to regulate or prohibit the arrival in or departure from this State, or the arrival in or departure from any of the towns, villages and cities thereof, of any such exposed or infected animal, and, at the cost of the owner thereof, to detain any domestic animal found in violation of any such regulation or prohibition, to adopt all such rules and regulations as may be by such several boards deemed necessary or expedient to enforce the authority hereby given; and said State live stock sanitary board is hereby expressly given authority to regulate or prohibit the shipment into this State of any domestic animal which in the judgment of said board may injure the health of live stock in this State: *Provided*, That neither said State live stock sanitary board nor any local board of health shall, by any rule or regulation thereof, prohibit the sale, disposal, or removal of any domestic animal of any person or persons from any place when such animal has no disease or has not been exposed to any contagious disease, and the fact that animals are upon the same premises with other animals having a contagious disease shall not of itself necessarily be construed as evidence of exposure to such a contagious disease as is had by said other animals.

Notice of outbreaks to be sent to board.

Minnesota shall forthwith give notice thereof to the local board of health of the town, village, or city wherein such animal is kept. Within twenty-four hours after any local board of health shall receive notice or have knowledge that any domestic animal is infected with any such disease, or has been exposed thereto, it shall give notice thereof in writing to the said State live stock sanitary board.

Rules and regulations of board to be published.

the minutes of the board so adopting such rules or regulations, and shall be published in a newspaper to be designated by the board making such rule or regulation and in the manner by such rule or regulation prescribed. All regulations now in force adopted by any board of health within this State under authority of any law existing prior to the passage of this act or relating to the matters covered by this act and not in conflict with this law are continued in force and are hereby declared to be rules and regulations of said State live stock sanitary board and the several boards of health of the towns, villages, and cities under this act until such times as others are adopted.

SEC. 7. It is hereby made the duty of the several local boards of health of the towns, villages, and cities of this State to cooperate with and assist said State live

SEC. 8. All authority conferred upon the State board of health by any law of the State of Minnesota concerning the prevention,

SEC. 9. Authority is hereby given to the State live stock sanitary board and to the several local boards of health of the towns, villages, and cities of this

SEC. 10. Any person who knows of or has reason to suspect the existence of any contagious or infectious disease in any domestic animal in the State of Minne-

SEC. 11. All rules and regulations adopted by said State live stock sanitary board or by any local board of health under the authority of this act shall be entered upon

The destruction of infected animals. Sec. 12. No animal shall be killed by any of the boards herein mentioned until it shall first have been adjudged to be infected with a contagious or infectious disease, either by a duly authorized agent of said State live stock sanitary board or by a veterinary surgeon selected by a local board of health; except that whenever, in the judgment of said State live stock sanitary board, the control or eradication of the disease renders it advisable to do so, said State live stock sanitary board may order killed and buried or otherwise destroyed any domestic animal which has been exposed to a contagious or infectious disease, although at the time not infected therewith.

Owner may protest against killing. Postmortem by experts. Appraisements.

Sec. 13. Whenever a domestic animal has been adjudged to be infected with a contagious or infectious disease, and has been ordered killed by said State live stock sanitary board or by a local board of health, the owner or keeper of such animal shall be notified thereof, and within twenty-four hours thereafter such owner or keeper may file a protest against the killing thereof with the board which has ordered such animal killed. Such notice shall state under oath that to the best of the knowledge and belief of the person making such protest, such animal is not infected with any contagious or infectious disease, whereupon, if such animal is killed notwithstanding such protest, a post mortem examination thereof shall be made by three experts, one of said experts to be appointed by said State live stock sanitary board, one to be appointed by the person making such protest, and the two thus appointed to choose a third. If upon such postmortem examination such animal shall be found to have been entirely free from contagious or infectious diseases, there shall be appointed three competent and disinterested men, one to be selected by said State live stock sanitary board, one by the person making such protest, and the third by the two already appointed, to appraise such animal at its cash value immediately before it was killed, and the amount thereof shall be paid to the owner of said animal out of the funds hereby appropriated for the purpose of carrying out this act. The appraisements made under this act shall be in writing and signed by the appraisers and certified by the local board of health and the said State live stock sanitary board, respectively, to the auditor of the State, who shall draw a warrant on the State treasurer for the amount thereof.

Payment of postmortem expenses. Sec. 14. The expense of the experts in making the postmortem examination herein provided for shall be defrayed by said State live stock sanitary board out of the moneys appropriated for the carrying into effect of this act, in case said experts upon examination find such animal to have been entirely free from contagious or infectious disease. If, however, upon such examination, such animal shall be found to have been infected with a contagious or infectious disease, then the expense of the expert appointed by said State live stock sanitary board and the third expert shall be paid by the said State live stock sanitary board out of the funds hereby appropriated for the carrying into effect of this act, and the expense of the other expert shall be paid by the person making the protest. The amount of such expense shall be fixed and allowed by the said State live stock sanitary board, and by it certified to the State auditor, who shall draw his warrant on the State treasurer for the amount thereof.

Certificate of expense to be filed. Sec. 15. Upon the filing of any appraisement hereinbefore provided for, it shall be the duty of the local board of health in the town, village, or city where such appraisement shall have been had to make a certificate under their hands of the number of days served by the appraisers in making their appraisement, and upon the filing of such certificate, the said certificate shall be forwarded to the State live stock sanitary board, and if by said board found to be correct, such fact shall be endorsed on the back thereof, and such certificate with such endorsement shall be filed with the State auditor, and the State treasurer shall pay to each of said appraisers the sum of two dollars (\$2) per day for his services as such appraiser upon the warrant of the State auditor, such payment to be made out of the funds herein appropriated.

Owner shall be paid for uninfected animals killed.

Sec. 16. Whenever any such animal which has not been adjudged to be infected is killed by order of said board, but not by the owner or keeper thereof, a postmortem examination thereof shall be made by experts appointed as aforesaid, and if found to have been entirely free from any contagious or infectious disease, the value of such animal shall be determined and paid for as hereinbefore specified.

Apportionment of cost of quarantine and destruction of diseased animals.

SEC. 17. The expense of the killing and burial, or destruction, of any diseased animal ordered killed by either of the boards aforesaid shall be borne by the town, village, or city where such animal was kept. The expense of the quarantine of any infected animal, or of any animal that has been exposed to infection, when taken from the possession of its owner or keeper, shall be borne, one-fifth by the town, village, or city where the animal was kept, and four-fifths by the State. When any animal is quarantined upon the premises of its owner or keeper, the expense thereof shall be borne by such owner or keeper. Whenever any animal is quarantined when being shipped into the State, the expenses thereof shall be borne by its owner or keeper. Whenever the owner or keeper of any domestic animal is liable for any expenses incurred under this act by the State live stock sanitary board or by any board of health in connection therewith, such board may have a lien on such animal for such expense, and may also maintain an action against such owner or keeper therefor.

Local boards must carry out orders of State board.

SEC. 18. It is hereby made the duty of the several local boards of health in this State to carry out and enforce all orders and directions of the State live stock sanitary board to them directed, and the State live stock sanitary board may require any two or more local boards to act together for the purpose of enforcing any of the provisions of this act.

Rules of State board shall supersede local regulations.

SEC. 19. Whenever the rules and regulations of the State live stock sanitary board made under authority of this act conflict with the rules and regulations made hereunder by any local board of health, those made by the State live stock sanitary board shall supersede those made by the local board.

Board may examine witnesses under oath.

SEC. 20. The State live stock sanitary board, or any member or duly authorized agent thereof, may examine or cause to be examined, under oath, all persons believed to possess knowledge of material facts concerning the existence or dissemination, or danger of dissemination, of disease among domestic animals; and for this purpose shall have all the powers vested in justices of the peace to take depositions and to compel witnesses to attend and testify.

Penalties for violating this act.

SEC. 21. Any person violating any provisions of this act or any rule or regulation made by the State live stock sanitary board, or by any local board of health, or any order made by any such board under the authority hereof, shall be guilty of a misdemeanor, and be punished by a fine of not less than twenty-five dollars (\$25) or more than one hundred dollars (\$100), or by imprisonment for not less than thirty (30) days or more than ninety (90) days. Any member of any local board of health who shall neglect or refuse to carry into effect the provisions of this act, or who shall neglect or refuse to carry out any directions of the State live stock sanitary board, or who shall neglect or refuse to enforce any rule or regulation made by the State live stock sanitary board, or by any local board of health under the authority hereof, shall be guilty of a misdemeanor and be punished by a fine of not less than twenty-five dollars (\$25) and not more than one hundred dollars (\$100), and each and every day's neglect or refusal to perform any duty imposed upon him by this act shall constitute a separate and independent misdemeanor. Complaints for violating the provisions of this act, or for violating any rule or regulation made by the State live stock sanitary board, or by any board of health under its authority, or by the said State live stock sanitary board, may be made by any member or authorized agent of any such board, or by any citizen of this State, or by any person directly interested.

Penalty for entering premises unlawfully.

SEC. 22. Whenever, during the prevalence in this State of any contagious or infectious disease among domestic animals, the owner shall post on his premises a notice forbidding all persons not authorized by said State live stock sanitary board or local boards of health to enter any building or enclosure on said premises without permission from said owner, it shall be a misdemeanor to enter upon said premises, punishable by a fine of not less than twenty-five dollars (\$25), nor more than one hundred dollars (\$100), or by imprisonment for not less than thirty (30) nor more than ninety (90) days.

Board to make annual report to governor.

SEC. 23. The said State live stock sanitary board shall make an annual report to the governor of Minnesota of all its proceedings and transactions for the preceding year, which said report shall be published by the State of Minnesota.

Books, papers, etc., to be turned over to board.

Sec. 24. The State board of health is hereby directed to turn over and deliver to said State live stock sanitary board, immediately upon the appointment of said board, all books, papers, documents, and files of said State board of health pertaining or relating to contagious or infectious diseases of domestic animals, either in Minnesota or elsewhere.

Transfer of appropriation.

Sec. 25. The annual appropriation made for the use of the State board of health by the provisions of section twelve (12) of chapter two hundred and thirty-three (233) of the laws of Minnesota for the year 1897 as amended by section two (2) of chapter three hundred and twenty-two (322) of the laws of Minnesota for the year 1901, is hereby transferred from said State board of health and granted and appropriated to said State live stock sanitary board for the carrying into effect the purposes of this act; and any money which at the time of the passage of this act remains unexpended out of said annual appropriation for fiscal year ending July 31st, 1903, is hereby transferred from said State board of health and granted and appropriated to said State live stock sanitary board.

Repealing clause.

Sec. 26. All acts and parts of acts inconsistent with this act are hereby repealed.

Sec. 27. This act shall take effect and be in force from and after its passage.

Approved April 22, 1903.

NEVADA.

AN ACT To prevent the spread of contagious diseases among live stock of the State of Nevada, and to quarantine against other States or infected districts.

The People of the State of Nevada, represented in Senate and Assembly, do enact as follows:

Proclamation of quarantine by governor.

SECTION 1. Whenever, upon the application of ten or more citizens of this State to the governor, asking for a proclamation of quarantine against any State or States, district or districts, infected by contagious diseases prevailing among live stock of said States or districts, the governor may issue a proclamation giving notice to such State or district, by mailing to the governor of said State or States, district or districts, where such disease exists a copy of said proclamation, in which it shall be stated that all diseased or infected, and all stock having been exposed to any infectious or contagious disease or diseases, are prohibited from entering within the borders of this State during the time of quarantine: *Provided*, That said prohibition shall not apply to any stock being transported through and beyond the limits of this State by any railroad company by permit or authority granted by any agent or inspector acting under the instruction and authority of the United States Government.

Governor may employ veterinarian.

SEC. 2. The governor shall at all times have the power to employ a veterinary surgeon to investigate epidemic and contagious diseases affecting live stock in this State.

Penalty for importing diseased live stock.

SEC. 3. Any person who in violation of the quarantine regulations expressed in section 1 of this act by bringing the live stock into this State from the State or district so quarantined, shall be guilty of a misdemeanor and shall, upon conviction thereof, be punished by a fine of not less than one hundred dollars (\$100) and not more than two thousand dollars (\$2,000), together with all the costs of treatment and disinfection, and the stock so treated and disinfected shall be held by the veterinary surgeon appointed by the governor for the full cost of treatment and fine imposed, and shall not be released until both fine and costs are paid.

Approved March 13, 1903.

NEW MEXICO.

AN ACT Relative to the duties of the cattle sanitary board.

Be it enacted by the Legislative Assembly of the Territory of New Mexico:

Section 197 of Compiled Laws of 1897 (same as sec. 17 of original law of 1884), amended.

SECTION 1. That section 197 of the Compiled Laws of the Territory of New Mexico for the year 1897 be, and the same is hereby, amended by striking therefrom the words "other than" contained in the second line of said section and by inserting the word

"including" in place thereof; and by striking therefrom the word "except" at the end of the twelfth line of said section and by inserting the word "including" in place thereof.

The original law was approved March 19, 1884, and the section in its entirety, as amended, is as follows:

SEC. 197. In all cases of contagious and infectious disease covered by this act, including Texas or splenic fever, existing or becoming epidemic on premises previously quarantined, as provided by this act, said board is authorized and empowered to cause the slaughter of cattle upon such premises which are known to be so diseased or have been exposed to such disease, when said veterinarian shall decide that the same is necessary for the sanitary protection of other cattle and shall so advise such board, and said board shall be of the same opinion and shall order such slaughter to be done: *Provided, however*, That no such cattle shall be slaughtered that have no disease nor have been exposed to any disease, including Texas or splenic fever. Such slaughter of cattle shall be done under the superintendence of said veterinarian or board, who, prior thereto, shall notify the nearest justice of the peace and deliver to him the order therefor; such justice shall thereupon select and summon before him three cattlemen of the neighborhood, who shall have no interest in the cattle to be slaughtered, to act as appraisers of the value of such cattle, and administer to each of them an oath to make a true, faithful, and impartial appraisal of the value of the cattle to be slaughtered without prejudice against or favor to anyone. Thereupon said appraisers shall inspect such cattle and make such appraisal thereof. They shall also return to each justice certificates of their valuation of each animal so appraised, containing an accurate description thereof, with brands, ear marks, wattles, age, sex, color, and class as near as may be. One of such certificates to be filed with the justice, one to be delivered to the owner of the cattle to be slaughtered, and one to be transmitted to the said board by said justice. The fees of justices of the peace for services herein provided shall be the same as for similar services as fixed by law, and said appraisers and all necessary employees for the slaughter of animals and destruction of their carcasses, as provided by this act, shall receive three dollars (\$3) per day and their necessary expenses while engaged therein, all of which shall be paid by said board upon their order. Such veterinary surgeon shall also superintend the destruction of the carcasses of each animal and each part thereof, which shall be by burning the same to ashes.

**Amendment to section 200 of
Compiled Laws of 1897.**

SEC. 2. That section 200 of the Compiled Laws of the Territory of New Mexico for the year 1897 be, and the same is hereby, amended by striking therefrom the word "not" at the end of first line of said section, and by inserting the word "including" in place thereof; and by inserting the words "or shall be likely to exist or shall be threatened" after the word "exist" in the third line of said section.

Section 200 in its entirety, as amended, is as follows:

SEC. 200. In case of epidemic or contagious disease (including Texas or splenic fever) may become known to the board to exist, or shall be likely to exist, or shall be threatened, within the Territory, and the board may deem it necessary to use more money than the present assessment (one-half of one mill on each dollar) may yield, then they may summon the governor, treasurer, and auditor of the Territory to meet as a Territorial cattle sanitary board, at the governor's, treasurer's, or auditor's office, in the city of Santa Fe, and if this board upon meeting shall determine it to be to the best interests of the cattlemen of the Territory to do so, they may order a levy not to exceed one-fourth of one per cent of the assessable value of cattle within the Territory, or they may issue bonds in the denomination of one hundred dollars (\$100), bearing interest not to exceed eight per cent, payable annually; interest and bonds are payable at the First National Bank of Santa Fe, N. M. Said bonds shall run from five to eight years and are payable at any time after five years. The bonds will be signed by the president of the cattle sanitary board and by the treasurer of the Territory, and by the latter registered in a book to be provided by the cattle sanitary board, which book shall be continued in the possession of the treasurer of the Territory and his successors. The governor of the Territory will preside at all meetings of the Territorial cattle sanitary board, and a record of each meeting will be made by the treasurer of the Territory and also by the secretary of the cattle sanitary board. The bonds shall be sold at the highest obtainable price. Whenever the Territorial cattle sanitary board may think best, they may order a levy not to exceed one-eighth of one per cent of the assessed value of cattle within the Territory, and continue said levy yearly until a sufficient sum is realized to pay said bonds with the yearly accruing interest. Said levy shall constitute a sinking fund for the payment of said bonds and for no other purpose. Said sinking fund shall be deposited with the Territorial treasurer, who shall give a good and sufficient bond, to be approved by the governor, for a sum equal to the bonds and interest. The levies

provided for by this act shall be made by the several county commissioners of the different counties at the expense of such counties making such levies. The Territorial treasurer shall pay said bonds in their numerical order. Notice of payment will be posted in the First National Bank of Santa Fe, N. M., sixty days before payment. The bonds when paid shall be destroyed by the treasurer and auditor of the Territory and a record of the same [kept?] by the treasurer. It shall be the duty of the governor to demand of and cause to be executed a bond by each of the members of the cattle sanitary board to the Territory of New Mexico with two or more sufficient securities, and in such sum as will cover the amount which may be raised and collected by the aforesaid levies, conditioned for the faithful disbursement of said moneys. In the event that either of said members do not execute said bonds within twenty days, his or their office will be vacant, and the governor will at once fill such vacancy and require the two bonds provided for in this act.

Approved February 12, 1903.

AN ACT To amend the laws relative to the sheep sanitary board.

Be it enacted by the Legislative Assembly of the Territory of New Mexico:

Amendment to section 160 of Compiled Laws of 1897.

SECTION 1. That section 160 of the Compiled Laws of New Mexico of 1897 be, and the same is hereby, amended by striking out the word "three" in the first line thereof and inserting in lieu thereof the word "five;" and by inserting the words "and two at large" after the word "districts" in the tenth line.

The above-mentioned section 160 in its entirety, as amended, is as follows:

SEC. 160. A sheep sanitary board, consisting of five (5) practical sheep raisers and owners is hereby created for the Territory of New Mexico, which Territory, for the purpose of this act, is hereby divided into three sheep sanitary districts, as follows: First district, Lincoln, Chaves, Eddy, Grant, Dona Ana, Sierra, and Socorro; second district, Valencia, Bernalillo, San Juan, Rio Arriba, Taos, and Santa Fe; third district, San Miguel, Guadalupe, Mora, Colfax, and Union. The governor shall nominate members of said board, one from each of the several districts and two at large, and appoint them by and with the advice and consent of the legislative council, who shall serve for the period of two years from the approval of this act and until their successors are appointed and qualified as hereinafter provided; and in case of any vacancy in said board from any cause, the governor shall fill such vacancy by appointment, and such appointee shall hold [office] only during the unexpired term for which he was appointed: *Provided*, That each member of such board must be a practical sheep man and owner of sheep and a bona fide resident within the district from which he is appointed, and his permanent removal therefrom to another district shall cause a vacancy in such board.

No Territorial inspection necessary if inspected by Government.

SEC. 2. The provisions of the act of the legislative assembly of the Territory of New Mexico, approved March 10, 1899, which appears as chapter thirty-three of the printed acts of the legislative assembly at its thirty-third session, are hereby so amended and modified as not to require any inspection of sheep coming into, or going out of, the Territory, as to their sanitary condition, when such sheep have been inspected by an inspector or an assistant inspector of the Bureau of Animal Industry of the Department of Agriculture, in accordance with the act of Congress entitled "An act to enable the Secretary of Agriculture to more effectually suppress and prevent the spread of contagious and infectious diseases of live stock, and for other purposes," approved February 3rd [2nd], 1903, and in accordance with the rules and regulations established, or which may be established from time to time, by the Secretary of Agriculture under the authority conferred on him by said act, and when such inspector or assistant inspector has issued a certificate showing that he has inspected such sheep in accordance with said act and said rules and regulations and has found them free from any infectious, contagious, or communicable disease; but the said act of the legislative assembly of New Mexico shall remain in full force as to all other sheep coming into, or going out of, the Territory of New Mexico.

Record must be kept of sheep imported. Fees for same.

SEC. 3. It is hereby made the duty of the sheep inspectors carefully to examine all sheep coming into the Territory of New Mexico from any other country, State, or Territory, for the purpose of ascertaining and making a record of all brands and marks on said sheep and of the name or names of the person or persons shipping or bringing said sheep into the Territory, and of the persons to whom within the Territory the said sheep are shipped or consigned,

and reports of such facts shall immediately be made by inspectors to the secretary of the sheep sanitary board, and the owner or person in charge of such sheep shall pay to the inspector a fee of three cents (3c.) per head for the making of such examination, record and report: *Provided, however,* That in the cases of sheep which have not been inspected by an inspector or assistant inspector of the Bureau of Animal Industry, as specified in the second section of this act, the fee of five cents (5c.) per head prescribed in section five of the act of the legislative assembly of New Mexico of March 10, 1899, referred to in said second section of this act, shall be considered as including the fee of three cents (3c.) per head fixed and prescribed by this section for making the examination, record, and report aforesaid.

Exporting sheep from Territory. Inspection, certificates, and fees.

SEC. 4. It is hereby made the duty of the sheep inspectors carefully to examine all sheep about to be shipped or driven out of the Territory for the purpose of ascertaining and making a record of all brands and marks upon said sheep, and no sheep bearing any of the marks by the law of this Territory declared to be unlawful shall be allowed to be shipped or driven out of the Territory, except under express authority of the sanitary board. The inspector shall also require each person so shipping or driving sheep out of the Territory to exhibit a bill or bills of sale, or authority in writing to ship or drive such sheep, executed as now provided by law for live stock, from the recorded owner of all marks and brands upon such sheep, unless such person is himself the recorded owner of such marks and brands. The inspector shall make a record, and report to the secretary of the board, of the number of the sheep so shipped or driven out of the Territory, of all brands and marks on such sheep and of the facts shown in such bill of sale or authority in writing as aforesaid, and shall give to the person in charge of such sheep a certificate setting forth the said facts, and the said person shall, before receiving such certificate, pay to the inspector a fee of five mills (5 m.) for each sheep so inspected. In case of any sheep about to be shipped or driven out of the Territory which have not been inspected by an inspector or assistant inspector of the Bureau of Animal Industry, and a certificate issued by such inspector or assistant inspector, as specified in the second section of this act, the Territorial inspector shall also examine said sheep as to their sanitary condition, and if fully satisfied that they are free from any contagious or infectious disease, he shall, upon payment to him of a fee of one cent (1c.) for each sheep, which fee shall be in full for all services performed under this section, give to the person in charge of said sheep a certificate or bill of clearance setting out the performance of everything required by this section, which certificate or bill shall authorize the taking of said sheep out of the Territory; and it shall not be lawful for any person, firm, or corporation to offer for transportation, nor shall any railroad company in this Territory accept or receive for transportation on its lines of railroad from this Territory to any place beyond its boundaries, any such sheep for the transportation of which a certificate or bill of clearance, as herein provided for, is not first obtained and exhibited to the railroad company by the shipper immediately before and at the place of shipment; and any railroad company violating the provisions of this act shall be held liable in the sum of five cents (5c.) per head for each and every head of sheep received by it for transportation and actually transported from this Territory to any place beyond its boundaries without such a certificate or bill of clearance, which sum shall be recovered for the use of the sheep sanitary fund upon the suit of the sheep sanitary board in any court of competent jurisdiction: *And provided further,* That in event any judgment should be recovered against any railroad company for damages because of its compliance with any of the terms of this act, such company shall be reimbursed in the amount of such judgment out of the sheep sanitary fund. The said inspector shall make report to the secretary of the board of every inspection made by him under the provisions of this section, which said report shall show the name of the shipper, the place of shipment, the place of destination, the number of sheep shipped, their marks, brands, and sanitary condition, and the date of shipping, together with name or names of any former owner or owners of such sheep, or any portion thereof, and the substance of the bills of sales made by such former owner or owners exhibited by the shipper, and any additional matters which may be required by the board.

Fee for sheep coming into Territory to graze.

SEC. 5. All sheep shipped or driven into the Territory of New Mexico for the purpose of being grazed during the whole or any portion of the year shall pay a fee of five cents (5c.) per head, to be collected by the sheep inspector at the time of the coming of said sheep into the Territory, or as soon thereafter as it may be discovered that they have so come into the Territory, and said fee shall be a lien on said sheep, and when collected shall be paid into the sheep sanitary fund; and unless such fee

is immediately paid or its payment secured to the satisfaction of the inspector, the inspector shall summarily take charge of the flock or flocks of sheep, as under attachment, and report the flocks to the board, and the board shall institute proceedings against said sheep as for the foreclosure of a lien, and against their owner, for the recovery of said fee and all costs and expenses incurred in caring for such sheep while in the custody of the inspector.

Fees collected to be used for expenses of inspection.

therein provided for, and for no other purpose.

SEC. 6. All fees collected under sections three and four of this act shall be used for the purpose of defraying the cost and expenses of inspections

Penalty for violating sections 8 and 4.

the certificate therein provided for, or by failing to pay the fees required by said sections, shall be deemed guilty of a misdemeanor, and shall be punished by a fine of not less than one hundred dollars (\$100) nor more than five hundred dollars (\$500), and, in the discretion of the court, also by imprisonment not exceeding six months.

SEC. 7. Any person violating the provisions of sections three and four of this act, whether by shipping or driving sheep out of the Territory, without first having obtained

Owners of sheep with contagious disease subject to penalty. Collection of same.

subject to penalty not exceeding the sum of one hundred dollars (\$100), which shall be a lien on such sheep, and shall immediately report the facts of the case fully to the board, and the board shall instruct the inspector as to the amount of penalty to demand and collect from such owner, or person, or sheep, and if the same be not paid within ten days after demand is made therefor, the inspector in the name of the board, or the board, may enforce the payment thereof by appropriate proceedings in any court of competent jurisdiction, which shall include the district court of the county where the office of the board may be, and the court may give judgment for any amount not exceeding the amount fixed by the board as aforesaid, and the amount so recovered shall be paid into the sheep sanitary fund, but the imposition and collection of the penalty herein provided for shall not be any bar to any criminal prosecution for violation of any other provision of law, nor shall these provisions be held to interfere with or repeal any other statutory remedies or proceedings looking to the suppression of contagious diseases among sheep. The court before which any such case is tried shall, as necessary to a judgment against defendant, require evidence of the existence of scab or other contagious disease among the sheep, of notice by the inspector to the owner or person in charge of the sheep, and of the action of the board in fixing the penalty, but the certificate of the secretary of the board shall be sufficient and conclusive evidence of the action of the board, and a certificate from the inspector, stating the fact, shall be prima facie evidence of the existence of scab or other contagious disease among the sheep.

SEC. 8. Whenever any inspector shall find any sheep infected with scab or other contagious disease, he shall notify the owner or person in charge of such sheep that he is

Sheep tax. Method of levying, etc.

each year order the levy of a tax upon the assessed value of all sheep in the Territory. Such order shall be made by the board on or before the first day of July in any year, and shall be certified to the Territorial auditor by the secretary of the board, and the amount of such levy shall by said auditor be certified to the board of county commissioners of each county, and such commissioners shall include said levy in their annual levies of taxes. Such special tax shall be collected in the several counties and paid to the Territorial treasurer in the manner provided by law for the collection and payment of other Territorial taxes. Such fund shall be kept separately by such treasurer and shall be used exclusively for the payment of any expenses properly incurred by the sheep sanitary board, and such fund shall be paid out by the Territorial treasurer on the order of said board only. Such special tax shall be assessed, levied, and collected at the expense of the several counties; and in case the county commissioners of any county shall fail or neglect to make the levy provided herein, they shall each become personally responsible to said fund in an amount equal to twenty-five per cent of said levy, to be collected from them and their bondsmen for the exclusive benefit of said fund.

SEC. 9. The sheep sanitary board shall in

Repealing clause.

SEC. 10. Section 168 of the Compiled Laws of 1897, and the amendment thereto contained in section 21 of the act of the legislative assembly of New Mexico, referred to in the second section of this act, are hereby repealed.

SEC. 11. All acts and parts of acts in conflict with this act are hereby repealed, and this act shall be in force from and after its passage.

Approved March 14, 1903.

NEW YORK.

AN ACT To amend article four of the agricultural law, by adding thereto three sections in relation to the slaughtering, sale, and transportation of calves and veal.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Law of 1898, etc., amended. SECTION 1. Article four of chapter three hundred and thirty-eight of the laws of eighteen hundred and ninety-three, entitled "An act in relation to agriculture, constituting articles one, two, three, four and five of chapter thirty-three of the general laws" as amended by chapter four hundred and ninety-one of the laws of eighteen hundred and ninety-eight, chapter one hundred and eighteen of the laws of nineteen hundred, and chapter three hundred and twenty-one of the laws of nineteen hundred and one, is hereby amended by adding at the end thereof three new sections to be numbered respectively sections seventy-e, seventy-f, and seventy-g, to read as follows:

Slaughtering and selling veal for food. SEC. 70-e. No person shall slaughter, for the purpose of selling the same for food, or expose for sale or sell within this State, or bring or cause to be brought into any city, town, or village within this State for food any calf or carcass of the same, or any part thereof except the hide, unless it is in good healthy condition and was at least four weeks of age at the time of killing. Any person or persons duly authorized by the commissioner of agriculture may examine any calf or veal found within this State offered or exposed for sale, or kept with intent to sell as food, and if such calf is under four weeks of age, or the veal is from a calf killed under four weeks of age, or from a calf in an unhealthy condition when so killed, he may seize the same and cause it to be destroyed or disposed of in such manner as to make it impossible to be thereafter used as food.

Shipping veal. SEC. 70-f. On and after the passage of this act it shall be unlawful for any corporation, partnership, person, or persons to ship to or from any part of this State any carcass or carcasses of a calf or calves, or any part of such carcass except the hide, unless they shall attach to every carcass or part thereof so shipped in a conspicuous place a tag, that shall stay thereon during such transportation, stating the name or names of the person or persons who raised the calf, the name of the shipper, the points of shipping, and the destination and the age of the calf.

Receiving veal for shipment by common carriers. SEC. 70-g. On and after the passage of this act no railroad company, express company, steamboat company, or other common carrier shall carry or receive for transportation any carcass or carcasses of calves, or any part of the same except the hide, unless the said carcass or carcasses or parts thereof shall be tagged as herein provided.

SEC. 2. This act shall take effect immediately.

Approved February 19, 1902.

AN ACT Making appropriation for the prevention and suppression of infectious and contagious diseases among domestic animals.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Appropriation for suppressing contagious diseases of animals. SECTION 1. Ten thousand dollars (\$10,000), or so much thereof as may be necessary, is hereby appropriated out of any moneys in the treasury not otherwise appropriated, to pay expenses incurred and to be incurred by the commissioner of agriculture under the provisions of the agricultural law in suppressing or stopping the spread of or preventing the existence of contagious and infectious diseases of domestic animals.

SEC. 2. This act shall take effect immediately.

Approved January 23, 1903.

NORTH CAROLINA.

AN ACT To prevent the spreading of disease among hogs in Currituck County [and other counties].

The General Assembly of North Carolina do enact:

Diseased hogs in certain counties may not run at large.

SECTION 1. That it shall be unlawful for any person or persons within the limits of Currituck County, west of Currituck Sound, and the counties of Wake, Camden, Tyrrell, and Lenoir owning hogs that have cholera or other infectious disease to permit the same to run at large.

Disposition of diseased carcasses.

SEC. 2. That the owner of hogs within the above limits that die with cholera or other infectious diseases, shall bury at least two feet under the soil or burn or have burned or buried said hogs at once.

Penalty. SEC. 3. That anyone violating the provisions of this act shall be guilty of a misdemeanor, and upon conviction be fined not less than five dollars (\$5) nor more than ten dollars (\$10), or imprisoned for not more than thirty days.

SEC. 4. That this act shall be in force from and after its ratification.

Ratified February 11, 1903.

OHIO.

AN ACT Relating to the board of live stock commissioners and its duties and powers. (On May 7, 1902, sections 4211-9, 4211-13, 4211-15, 4211-16, 4211-17, and 4211-18 of the old law were amended. A copy of the entire law, as amended, has been furnished by W. W. Miller, secretary of the State board of agriculture, and is as follows:)

Be it enacted by the General Assembly of the State of Ohio:

State board of agriculture to control diseases of animals.

SEC. 4211-9. The Ohio State board of agriculture shall be and is hereby constituted the board of live stock commissioners for the promotion and protection of the live stock interests of the State and the prevention of the spread of infectious and contagious diseases among domestic animals and the extermination of the same; and to cooperate with the Bureau of Animal Industry of the United States Department of Agriculture in the suppression and extirpation of contagious and infectious diseases among domestic animals. The board may elect such officers as it may deem necessary, and shall have power in its organization and work to prescribe such rules and establish such regulations, not in conflict with law, as it may deem necessary to secure strict quarantine and otherwise prevent the spread of infectious and contagious diseases among live stock and extirpate the same, so far as it may be able to do.

Duty as to extirpating diseases.

SEC. 4211-10. The board of commissioners are authorized to use all proper means to prevent the spread of dangerous and fatal diseases among domestic animals, and to provide for the extirpation of such diseases; and in the event of any such contagious or infectious disease breaking out in this State, it shall be the duty of all persons owning or having in charge animals infected with the same, to immediately notify said board of commissioners, or some member thereof, of the existence of such disease, and thereupon it shall be the duty of said board immediately to cause proper examination thereof to be made by a competent veterinarian; and if said disease shall be found to be a dangerously contagious or infectious malady, the board shall order the diseased animals, and such as have been exposed to the contagion, to be strictly quarantined in charge of such person as the board, or an authorized member thereof, shall designate, and to order any premises or farms where such disease exists, or has recently existed, to be put in quarantine, so that no domestic animal subject to such disease be removed from or brought to the premises or places so quarantined; and the board shall prescribe such regulations as they may deem necessary to prevent the contagion from being communicated in any way from the premises so quarantined.

Bodies of dead animals.

SEC. 4211-11. The bodies of all dead animals shall be buried or burned by the owners thereof, as provided by law.

Penalty for disposing of or importing diseased animals and for failing to report outbreaks.

SEC. 4211-12. That any person having in his possession, or under his care, any animal which he knows, or has reason to believe, is affected with a dangerously contagious or infectious disease, and does not, without unnecessary delay, make

known the same to said board, or to some member thereof, or to the sheriff or constable of the proper county, to be by him communicated to said board; or any person or corporation who shall bring into this State, or sell or dispose of any animal, knowing the same to be affected as aforesaid, or any animal having been exposed to such contagion, within three months of such exposure, or shall move the animal so diseased or exposed from the quarantine to which it was ordered by the board of commissioners, or shall move any animal to or from any district in this State declared to be infected with such contagious disease, or shall bring into this State any animal of the kind diseased from any district outside of the State that may at any time be legally declared to be affected with such disease, without the consent of said board, except under such conditions as are or may be prescribed by said board, shall, upon conviction of either of the aforesaid offenses, be fined in any sum not exceeding five hundred dollars (\$500). And all proper expense incurred in the quarantining of animals under the provisions of this act shall be paid by the owners thereof, and if the same is refused, after demand made by order of the commissioners, an action may be brought to recover the same with costs of suit, which action may be in the name of the State of Ohio, for the use of the board of live stock commissioners. It shall be the duty of all sheriffs and constables to execute within their several counties all lawful orders of the said commissioners.

Records of board; report, compensation, and expenses.

stock and report the same to the governor on the first Monday of November annually, and shall publish and distribute such bulletins and reports as may be deemed of general interest and information. The supervisor of public printing shall provide for such printing as the board may deem necessary and desirable to benefit the live stock interests of the State under the same provisions as are made for other State printing. Each member of said board shall receive for his services the sum of three dollars (\$3) per day and necessary traveling expenses for each day he is actually engaged in the investigation and eradication of diseases of domestic animals by the direction of the board.

Governor may prohibit importation of diseased animals.

commissioners, shall believe that any dangerous, contagious, or infectious disease has become epidemic in certain localities in other States, Territories, or countries, or that there are conditions which render domestic animals of such infected district liable to convey such disease, he shall, by proclamation, prohibit the importation of any live stock of the kind diseased into the State, except under such regulations as may be prescribed by the State board of live stock commissioners and approved by the governor.

Appraisement of condemned animals.

disease among the live stock of the State, to destroy animals affected with or which have been exposed to any such disease, it shall determine what animals shall be killed, and shall appraise or cause the same to be appraised, by disinterested citizens as hereinafter provided, and cause such animals to be killed, and their carcasses to be disposed of as in the judgment of the commission will best protect the health of the domestic animals of the locality; provided, that no animal shall * * * be slaughtered under the provisions of this act unless first examined by a competent veterinarian in the employ of the commission and the disease with which it is affected, or to which it has been exposed, adjudged to be a dangerous and contagious malady.

Appointment of veterinarian.

SEC. 4211-16 A. The board of live stock commissioners shall appoint a competent veterinarian, whose compensation shall be fixed by the board; such veterinarian to perform all duties prescribed by the board and be subject to such rules and regulations as it may adopt. In case of an outbreak of animal disease, the board may, if it is deemed advisable, appoint temporarily additional veterinarians, or other persons for any special work in furtherance of the live stock interests of the State, and fix their compensation.

Inspection and protection of live stock.

SEC. 4211-16 B. In the enforcement of any of the provisions of this act or any other laws relating to the board of live stock commissioners, and in the enforcement of the rules and regulations that may be adopted under the authority of this act, the board of live stock commissioners, or any of them, or their authorized officers,

agents, or employees, shall have authority to enter upon any public or private premises, or within any building where live stock is housed, or to enter any railway car or any boat or other conveyance used in the transportation of live stock, for the purpose of inspection and for the protection of the live stock of the State.

General penalty. SEC. 4211-16 C. The failure of any individual, company, or corporation to comply with the rules of the board of live stock commissioners, or to respect its regulations with regard to diseased animals, when notified so to do, shall subject the offender to a penalty of not less than fifty dollars (\$50) nor more than five hundred dollars (\$500), to be recovered by civil action in the county where the offense is committed or in the county of Franklin, and in addition to the penalty above provided, a person violating any of the provisions of this act shall be deemed guilty of a misdemeanor, and on conviction shall be fined not less than fifty dollars (\$50) nor more than two hundred dollars (\$200), such fines and penalties to be collected in the name of the State of Ohio for the use of the board of live stock commissioners.

Cooperation with Bureau of Animal Industry.

SEC. 4211-16 D. The board of live stock commissioners is authorized to accept on behalf of the State the rules and regulations prepared by the Commissioner [Secretary] of Agriculture under and in pursuance of section three of an act of Congress approved May 29, 1888, entitled "An act for the establishment of a Bureau of Animal Industry, to prevent the exportation of diseased cattle and to provide means for the suppression and extirpation of pleuropneumonia and other contagious diseases among domestic animals," and to cooperate with the authorities of the United States in the enforcement of the provisions of such act.

Powers of Government inspector.

SEC. 4211-16 E. The inspector of the Bureau of Animal Industry of the United States shall have the right of inspection, quarantine, and condemnation of animals affected with any contagious, infectious, or communicable disease, or suspected of being so affected, or that have been exposed to any such disease; and for these purposes are authorized and empowered to enter upon any ground or premises in the State. They shall have power to call upon any constables and peace officers to assist them in the discharge of their duties in carrying out the provisions of said act of Congress; and it is made the duty of said officers to assist them when so requested. The inspectors shall have the same powers and protection as peace officers while engaged in the discharge of their duties.

Compensation for animals destroyed.

SEC. 4211-17. In case of destruction of any animal under the provisions of this act, the compensation to be made for the same by the State shall be computed upon the basis of the actual value of the diseased animal, if any, at the time of slaughter; for any animal that has been kept in the same building or enclosure two-thirds of such value, and in case of other animals destroyed for the extinction of such disease, the full value of the same without reference to the suspicion of contagion; provided, that no compensation shall be made to any person who may have brought animals into the State affected with such contagious disease, or from a district in which such contagious disease existed, or who may have wilfully concealed the existence of such disease among his stock or on his premises, or may have by wilful neglect or purposely contributed to the spread of such contagion; and in appraising animals to be slaughtered as herein provided, no allowance shall be made on account of such animals being thoroughbred, or pedigree stock.

Method of paying claims.

SEC. 4211-18. All claims against the State by owners of animals slaughtered under the provisions of this act shall, when approved by the board of live stock commissioners, be reported by said commission to the governor, to be by him communicated to the legislature with the recommendation, if the matter is approved by him, that the proper appropriation be made to pay such claims.

WHEREAS All cattle wintered in the States of Florida, South Carolina, North Carolina, Georgia, Alabama, Mississippi, Louisiana, Tennessee, Arkansas, Texas, and the Indian Territory are infected with a germ which renders them capable, except during the frost of winter, of infecting northern cattle with a malady commonly known as "Texas fever," while they show no manifestation of disease; therefore,

Closed season for Texas fever cattle.

SEC. 4211-19. During the months of March, April, May, June, July, August, September, and October no cattle shall be permitted to be driven into this State from any of the above-mentioned States or Indian Territory, or that shall have been wintered therein, nor shall any person or company bring, or cause to be conveyed into this State by railway or otherwise, any such cattle under said conditions, except as specified in the next section of this act.

Can not be unloaded, etc. SEC. 4211-20. Any railroad or other transportation company conveying into or through this State, or any stock-yard company receiving such cattle during the months aforesaid, will not be permitted to unload the same in this State for any other purpose than to be fed and watered or for immediate slaughter, and in yards and premises especially provided for that purpose, into which the northern cattle will not be permitted to enter. And the location and arrangement of the said yards and premises and the disinfection of the cars and quarters used in the transportation of such cattle shall be governed by the rules and regulations prescribed by the board of live stock commissioners.

Penalty. SEC. 4211-21. Any person or corporation that shall bring or cause to be brought or driven into this State any cattle wintered in the States or Territory above mentioned, or to be driven or conveyed otherwise than as herein specified, shall, upon conviction thereof, be fined in any sum not less than one hundred dollars (\$100), nor more than one thousand dollars (\$1,000), and shall, moreover, be liable for all damages that may be occasioned on account of other cattle being infected with said disease.

Duty of transportation companies; penalty for violation. SEC. 4211-22. It shall be the duty of all railway and other transportation companies bringing into and unloading in this State cattle, otherwise than as specified in section two (4211-20) of this act, during the months above specified, to require a statement to be made in their shipping bills, showing in what State or Territory the cattle shipped were wintered; and it shall be the duty of every railroad company bringing into this State cattle, which may unload such cattle for any other purpose than to be fed and watered as specified in section two (4211-20) of this act, to leave at the office of such company nearest the point where such cattle may be unloaded, a copy for public inspection of the statement above required, showing where the same were wintered; and any company or corporation neglecting to comply with the provisions of this section, shall, upon conviction thereof, be fined in any sum not exceeding five hundred dollars (\$500).

Prosecution for offenses hereunder. SEC. 4211-23. Upon the request of the board of live stock commissioners it shall be the duty of the prosecuting attorney of any county in which the suit may be brought to begin and prosecute any action for the violation of the provisions of this act and the rules and regulations of the board of live stock commissioners. Proceedings against any railway company under this act may be had in any county in this State through which any portion of such company's road may pass or in which its principal office may be situated; and process may be served by leaving a copy at the office of such company within such county.

Penalty for disposing of or secreting glandered animals. SEC. 4211-24. Any person owning or having in his charge any horse, mule, or ass that he knows or has reason to believe is affected with the disease known as glanders or farcy, or that has been adjudged to be so affected by the State board of live stock commissioners, upon a report made to said board by a competent veterinary surgeon, in their employ, after a careful examination of such animal, who shall sell or otherwise dispose of or secrete the same, or shall fail to keep such animal securely isolated so that contact with other horses, mules, or asses shall not be possible, shall, upon conviction of either of said offenses, be fined in any sum not exceeding five hundred dollars (\$500), and shall moreover be liable for all damages sustained by reason of the same.

Compensation for destruction of glandered animals. SEC. 4211-25. In case the live stock commissioners shall order the destruction of any animal affected with glanders or farcy in the chronic stage of the disease, which may be adjudged capable of rendering some service, the board may cause the animal to be appraised and order such compensation to be paid out on the order of the live stock commissioners, on the warrants of the auditor of State, out of any funds in the treasury to the credit of the live stock commission, as in the judgment of the commissioners may be just, not exceeding its cash value: *Provided*, The horse was not diseased when passed in possession of the owner.

Penalty for allowing diseased sheep to run at large. SEC. 4211-26. Any person owning or having in charge any sheep affected with foot-rot or scab who shall suffer the same to run upon any highway, common, or other uninclosed ground, or shall sell such sheep, knowing or having reason to believe them to be diseased, without disclosing the fact to the purchaser, shall, upon conviction of either of said offenses, be fined in any sum not exceeding one hundred dollars (\$100), and be liable to parties injured for all damages sustained.

Duties of carriers and owners of stock yards.

Sec. 4212. All railway companies and owners of steamboats used in conveying live stock and owners of stock yards and other premises that may be occupied by such stock, shall, immediately upon discovering any contagious disease among stock occupying such cars, boats, yards, or other premises, take all possible measures to prevent such diseased stock from communicating the contagion to other stock, and shall moreover cause all such cars, boats, yards, and premises to be thoroughly disinfected before the same shall be occupied by other stock. Every corporation and company, their officers and employees, or individuals violating the provisions of this section, shall pay a penalty not exceeding five hundred dollars (\$500), to be recovered in any court of competent jurisdiction, and shall also be liable to parties injured for all damages that may be occasioned thereby.

PENNSYLVANIA.

AN ACT To encourage the repression of tuberculosis of cattle, and to provide for the disposition of the carcasses of meat-producing animals that are infected with tuberculosis to a degree that renders their flesh unfit for use as food.

Be it enacted, etc.:

Inspection of carcasses for tuberculosis.

SECTION 1. That whenever it comes to the knowledge of the secretary of the State live stock sanitary board, or an agent of that board who is authorized to inspect animals, that a meat-producing animal killed for food was found to be infected with tuberculosis, or with a disease resembling tuberculosis, it shall be the duty of the secretary of the State live stock sanitary board, either himself or by deputy, or of an authorized agent of the State live stock sanitary board, to make an inspection of the said dead animal and its parts, for the purpose of ascertaining whether it is or was infected with tuberculosis, and, if infected, to what extent.

Disposition of diseased carcasses.

Sec. 2. If it shall be found that the animal, from which the carcass or meat came, was infected with tuberculosis or other infectious disease, and to a degree that renders the flesh unfit for use as food, the said dead animal, carcass, or meat, shall be condemned and shall be disposed of by the use of any method that is approved by the State live stock sanitary board. For the guidance of inspectors of animals and meats, and of agents of the State live stock sanitary board, rules for the inspection of the carcasses of meat-producing animals may be promulgated by the State live stock sanitary board, or, in the absence of such rules, the rules of the United States Bureau of Animal Industry, that cover the inspection of animals and carcasses for tuberculosis in abattoirs under Federal inspection, shall be observed.

Certificate and appraisement.

Sec. 3. When it is decided by a meat inspector, approved in respect to competency and reliability by the secretary of the State live stock sanitary board, or by a member or agent of the State live stock sanitary board, and certified by him in writing on an official form that shall be provided for this purpose by the State live stock sanitary board, that the flesh of a meat-producing animal is unfit for use as food, on account of the fact that the animal from which it came was infected with tuberculosis to an injurious degree, the said meat or carcass may be appraised by agreement between a member or agent of the State live stock sanitary board and the owner or his agent, or, if an agreement can not be made, three appraisers shall be appointed, one by the owner or his agent, one by the State live stock sanitary board or its authorized agent, and the third by the two so appointed, who shall, under oath or affirmation, fairly and impartially appraise the meat or carcass, taking into consideration its apparent market value at the time of appraisement: *Provided, however,* That such appraised valuation shall not exceed five cents (5c.) per pound, nor twenty-five dollars (\$25) for the entire carcass.

How appraised valuation shall be paid.

Sec. 4. The amount of the agreed or appraised valuation shall be paid by the State live stock sanitary board in the same manner as other expenses of said board are paid, upon the presentation of satisfactory certificates of condemnation and valuation, and satisfactory evidence in writing that the condemned animal has been continuously in the State of Pennsylvania for not less than four months prior to slaughter, and that the carcass was disposed of in a way that had been approved by the State live stock sanitary board.

Approved March 25, 1903.

AN ACT To provide for the investigation of the diseases of domestic animals, and making an appropriation therefor.

Be it enacted, etc.:

\$25,000 for investigating diseases, especially tuberculosis of cattle.

same is hereby specifically appropriated, out of any money in the treasury not otherwise appropriated, for the purpose of conducting investigations concerning the causes, nature, treatment, and prevention of the diseases of the domestic animals of the Commonwealth of Pennsylvania, and especially for the investigation of tuberculosis of cattle, and of improved measures planned to check or repress this disease, with the object of discovering new facts, which may be applied advantageously and profitably by the owners of live stock and those engaged in the care and rearing of animals.

Work to be under direction of State live stock sanitary board.

board is hereby authorized to make such provision for and conduct such work of investigation as is deemed necessary for the purpose of discovering the most efficient, economical, and practical means of avoiding and suppressing the diseases of the domestic animals of this Commonwealth, and the practical deductions from such work shall upon the order of the secretary of agriculture be published as a part of the annual report of the department of agriculture, or as bulletins from said department: *Provided, however,* That all expenses incurred under the provisions of this act shall first be approved by the governor and the secretary of agriculture. The said appropriation is to be paid upon the warrant of the auditor-general on the presentation of specifically itemized vouchers and the written approval of the governor and secretary of agriculture as herein provided.

Approved May 15, 1903.

PORTO RICO.

AN ACT Providing for the payment of the value of animals found to be suffering from glanders and which are ordered to be killed.

Be it enacted by the Legislative Assembly of Porto Rico:

Order of 1899 respecting appraisements repealed.

treasuries two-thirds of the value of the appraisement made on cattle which must be killed because of being found to be suffering from glanders, anthrax, rabies, or tuberculosis is hereby repealed.

SEC. 2. All laws or parts of laws in conflict with this act are hereby repealed.

SEC. 3. This act shall take effect from and after its passage.

Approved February 28, 1902.

AN ACT To prevent contagious and infectious diseases.

Be it enacted by the Legislative Assembly of Porto Rico:

Regulations for quarantine.

SEC. 1. That the governor, upon the recommendation of the superior board of health, is authorized and empowered to establish, maintain, and enforce such local quarantine, sanitary, and other regulations as he may deem necessary to protect the health and safety of the people or domestic animals of the island from all contagious or infectious diseases, and by proclamation to designate the foreign or domestic ports against which sanitary or quarantine regulations shall be enforced, or with which all intercourse shall be prohibited.

Penalty for violating orders. SEC. 2. Any person who shall violate any order or proclamation so issued by the governor or any part thereof shall be liable to punishment according to the provisions of the penal code. The police shall enforce and make effective all such quarantine, sanitary, or other regulations or proclamations.

Regulations for domestic animals. SEC. 3. The superior board of health shall prepare regulations for the treatment, quarantine, and destruction of domestic animals suffering from infectious or contagious diseases.

Power of arrest and prosecution. SEC. 4. The president of the board of health, members of the superior board of health, and insular health inspectors shall have the power to arrest and prosecute any person offending the above-mentioned regulations, proclamations, or any part of them.

Repealing clause. SEC. 5. All laws, royal decrees, general orders and parts thereof in conflict with the provisions of this act are hereby repealed.

SEC. 6. That this act shall take effect from and after its passage.

Approved March 1, 1902.

AN ACT To establish a penal code for Porto Rico.

Be it enacted by the Legislative Assembly of Porto Rico:

Title of act. SECTION 1. That this act shall be known as the "Penal Code of Porto Rico."

* * * * *

Penalty for selling diseased animals. SEC. 351. Any person who shall knowingly sell, or offer for sale, or use, or expose, or who shall cause or procure to be sold or offered for sale, or used, or exposed, any horse, mule, or other animal having the disease known as glanders, or any other contagious or infectious disease, shall be guilty of a misdemeanor.

Diseased animals must be destroyed. SEC. 352. Every animal having glanders or any other contagious or infectious disease shall at once be deprived of life by the owner or person having charge thereof, upon discovery or knowledge of its condition, and any such owner omitting or refusing to comply with the provisions of this section shall be guilty of a misdemeanor.

* * * * *

Imported animals must be inspected on arrival. SEC. 354. Every person who imports into Porto Rico any cattle, horses, mules, or asses, after the governor has made proclamation holding in quarantine for the purpose of inspection for contagious or infectious diseases such animals, and allows the same or any of them to leave the place of their first arrival in Porto Rico, until they have been examined by the insular veterinary surgeon, and a certificate has been obtained therefrom that such animals are free from disease, or permits any such animals to run at large, or to be removed, or to escape before such certificate has been received, is punishable by a fine not exceeding five hundred dollars (\$500).

Penalty for transporting animals not inspected. SEC. 355. Every person who, after the publication of such proclamation, knowingly receives or transports within the limits of Porto Rico any animal mentioned in the preceding section before the certificate mentioned therein has been given, is punishable by a fine not exceeding two thousand dollars (\$2,000).

Penalty for failure to report disease. SEC. 356. Every person who owns or has the custody of any cattle, horses, mules, or asses infected with a contagious disease, and fails to immediately report the same to the insular health authorities, or conceals the existence of such disease, or attempts to do so, or wilfully obstructs or resists the said health authorities in the discharge of their duty as provided by law, or sells, or gives away, or uses the meat or milk, or removes the skin or any part of such animal, is punishable by fine not exceeding three hundred dollars (\$300) or imprisonment in jail not exceeding one year, or both, in the discretion of the court.

Violation of quarantine a misdemeanor. SEC. 357. Every person who shall violate the terms of any proclamation issued by the governor in accordance with law and in relation to public health, or who shall violate local quarantine, sanitary, or other regulations issued under authority of law, shall be guilty of a misdemeanor and shall be punishable accordingly.

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Approved March 1, 1902.

SOUTH CAROLINA.

AN ACT To prohibit the importation of diseased stock into this State.

Be it enacted by the General Assembly of the State of South Carolina:

Unlawful to import stock with contagious disease. SECTION 1. That from and after the passage of this act it shall be unlawful for any person, firm, or corporation to knowingly import into this State any stock with contagious diseases, except distemper.

Penalty. SEC. 2. That any person, firm, or corporation violating the provisions of this act shall be deemed guilty of a misdemeanor, and, upon conviction, shall be fined not less than one hundred dollars (\$100) and not more than five hundred dollars (\$500), or shall suffer not more than twelve months' imprisonment.

Approved February 21, 1903.

TEXAS.

AN ACT To amend article 822 of chapter 4, Title XVII, of the Penal Code of the State of Texas—Of infectious diseases among animals.

Be it enacted by the Legislature of the State of Texas:

Counties exempt from art. 822, chap. 4, Title XVII, of Penal Code. SECTION 1. That article 822 of chapter 4, Title XVII, of the Penal Code, be amended so as to hereafter read as follows: Article 822.

The counties of Freestone, Gonzales, Morris, Titus, Cass, Marion, Bowie, Red River, Trinity, San Jacinto, Polk, Anderson, Van Zandt, Cameron, Collin, Colorado, Grimes, Houston, Webb, Encinal, Hunt, Hopkins, Ellis, Dallas, Rockwall, Denton, Fannin, Henderson, Brazos, Smith, Panola, Gregg, Lamar, Wood, Rains, Limestone, Cooke, Brown, Comanche, Cherokee, Mills, Montgomery, Shelby, Lee, Burleson, Rusk, Lavaca, Milam, Wise, Upshur, Robertson, Camp, Parker, Franklin, Navarro, Karnes, Wilson, Atascosa, Harrison, San Augustine, Sabine, Fayette, Austin, Leon, Madison, Hill, Bosque, Waller, Fort Bend, Washington, Guadalupe, Caldwell, Hays, Tarrant, Johnson, Clay, Montague, Erath, Hood, Somervell, Bastrop, Harris, Harrison, Orange, Jefferson, Hardin, Liberty, Chambers, Newton, Tyler, Jasper, Kaufman, Nacogdoches, Dewitt, Victoria, Jackson, Calhoun, Refugio, Goliad, and Aransas are exempted from the provisions of this chapter.

Approved March 31, 1903.

Takes effect ninety days after adjournment.

UTAH.

AN ACT To establish a State board of sheep commissioners, create the office of State sheep inspector, provide for the control and suppression of scab and other infectious diseases in sheep, and to provide revenue to enforce the same.

Be it enacted by the Legislature of the State of Utah:

Sheep commissioners and sheep inspector created. SECTION 1. That a State board of sheep commissioners and the office of State sheep inspector be and the same are hereby created.

Compensation, etc., of commissioners. SEC. 2. The State board of sheep commissioners, hereinafter called the board, shall consist of five members, all of whom shall be experienced wool growers, said members to be appointed by the governor and to hold their office for two years, or until their successors are duly appointed and qualified. They shall receive for their services the amount of (three dollars) \$3 per diem and their actual traveling expenses while in attendance at meetings of said board, to be paid out of the sheep-inspection fund hereinafter provided for.

Salary, etc., of sheep inspector. SEC. 3. The State sheep inspector, who must be an experienced wool grower, shall be appointed by the governor, and shall hold office for two years, and until his successor is appointed and qualified. His salary shall be (one thousand five hundred dollars) \$1,500 per year, and actual traveling expenses, which salary and expenses shall be

paid from the State treasury. He shall give a bond to the State in the sum of (five thousand dollars) \$5,000 for the faithful performance of his duties.

Rules and regulations of board. SEC. 4. The board is empowered to make rules and regulations for governing itself and for the enforcement of the provisions of this act, and is authorized to adopt on behalf of the State the rules and regulations of the United States Bureau of Animal Industry, relating to the control and suppression of diseases in sheep, and to cooperate with the officers of said Bureau in the enforcement of such rules and regulations. The board shall appoint a secretary, prescribe his duties, and fix his salary, which shall not exceed seven hundred and fifty dollars (\$750) per annum. The board shall maintain an office, which shall also be the office of the State sheep inspector. The maintenance of such office and the secretary's salary shall be paid from the State treasury in the same manner as the salaries and expenses of State officers. The board shall fix the rate of tax to be levied as provided for in section 5 of this act, and shall send notice of the same to the county commissioners of the several counties in the State on or before the 1st day of May in each year. The board shall audit all bills of salaries and expense incurred in the enforcement of this act that may be payable from the sheep-inspection fund, and, if found correct, shall certify the same to the State auditor, who shall draw a warrant on the State treasurer in favor of the party or parties entitled thereto. The board shall make an annual report in writing to the governor on or before the 31st day of December in each year, giving a statement of the transactions of the board, and facts relating to the condition of the sheep industry in the State. The board shall have power to order an inspection or quarantine of any sheep in the State, compel dipping at such times and as often as it deems necessary to insure a suppression of scab, and divide the State into such districts as may be necessary for the enforcement of this act.

Rate of tax. SEC. 5. The board of county commissioners, at the time of the annual levy of taxes, must, at the request of the board, levy the rate of tax recommended by the board, not to exceed four mills (4m.) on the dollar on all sheep assessed in their respective counties, according to the assessed valuation of the same, said tax to be collected as other taxes and paid to the State treasurer, who must keep the same in a separate fund, to be known as the sheep-inspection fund.

Duties of inspector; pay and powers of deputies. SEC. 6. The State sheep inspector shall have charge of the enforcement of the provisions of this act, and of all rules and regulations made and adopted by the board. He shall appoint such deputies as may be necessary, by and with the consent of the board; and said deputies, before entering upon the duties of their office, shall file a bond in the sum of (one thousand dollars) \$1,000 for the faithful performance of their duties, with and to be approved by the board. Such deputies shall receive (five dollars) \$5 per diem and actual traveling expenses incurred in the performance of their duty, to be paid from the sheep-inspection fund. The State sheep inspector and each deputy must keep a book, to be known as the inspection record, in which they must enter their official acts. Such record must show the name of the owner of every flock of sheep inspected, the time when the same was inspected, the amount collected from sheep coming in from other States and Territories, and all orders relating thereto. They shall have the right at all times to enter any premises, farms, fields, pens, slaughterhouses, buildings, or cars where any sheep are quartered, for the purpose of examining them, in order to determine whether they are affected with any infectious or contagious disease.

Inspector to report. SEC. 7. The State sheep inspector shall report to the board in writing as often and at such times as he may be requested by said board. The deputy inspectors must report to the State sheep inspector whenever he so requires.

Duties of deputies. SEC. 8. Each deputy inspector must inspect all sheep within the district assigned to him, when so ordered by the State sheep inspector, and must make and issue a certificate or bill of health for all sheep found free from disease, describing the sheep, with the marks and brands thereon, which certificate shall entitle the owner or agent in charge to pass with such sheep from one district to another in the State.

Owner to report infected sheep. SEC. 9. Whenever any sheep shall become infected with scab or any other infectious or contagious disease, the owner or agent in charge must immediately notify the State sheep inspector.

Diseased sheep to be quarantined. SEC. 10. When sheep are found diseased, or have been exposed to disease, by having them corralled, herded, or grazed in the same place with sheep that have been dis-

eased or quarantined, regulations for their quarantine must be made at once by the State sheep inspector, or one of his deputies, who must define the place and limits within which such sheep may be grazed, herded, or driven, and such sheep must be held in quarantine until pronounced cured from disease by the State sheep inspector or one of his deputies. The expense of dipping, hand dressing, spotting, feeding, and taking care of all sheep quarantined under the provisions of this act must be paid for by the owner or agent in charge of such sheep.

Sheep must be dipped. Formulas. SEC. 11. All sheep in the State must be dipped at such time or times as may be ordered by the board. Such dipping shall be done under the supervision of the State sheep inspector or one of his deputies. The dip used in all cases must be a lime and sulphur dip, or a sulphur and tobacco dip, the formula of each to be as follows:

1. A lime and sulphur dip made with 8 pounds of fresh lime, and 25 pounds of flowers of sulphur, or 32 pounds of native sulphur, to 100 gallons of water; the lime and sulphur to be boiled together for not less than two hours.

2. A tobacco and sulphur dip made from "Scab cure," "Black leaf," or "Laidlaw and McKill's Tobacco Extract," to be used in such quantities as prescribed by directions for using such dips, with 16 pounds of flowers of sulphur, or 24 pounds of native sulphur, to 100 gallons of water. Clean, pure water must be used in all cases, and the dip kept at a temperature from 110 to 115 Fahrenheit, the sheep to be kept in the vat from two to three minutes: *Provided*, That if the formulas required by the Bureau of Animal Industry of the United States for dipping sheep shall be changed hereafter, that the board may adopt the same in lieu of the foregoing formulas.

Penalty. SEC. 12. Any person or persons owning or having charge of any dipping vat or vessel in which sheep are dipped, and every owner of sheep or agent in charge of them, who shall refuse or neglect to dip all sheep in the manner prescribed in the preceding section, or who shall fail to observe any and all rules and regulations made and adopted by the board in accordance with the provisions of this act, shall be liable to the fines and penalties imposed hereinafter in this act.

Sheep brought into State. SEC. 13. When any owner or person in charge of sheep desire to bring such sheep into this State from an adjoining State or Territory, they shall notify the State sheep inspector in writing of such intention ten days before entering the State, stating the time and place where such sheep shall enter: *Provided, however*, That [owners of] sheep in transit on the cars shall not be required to give such notice unless they shall remain in the State or are unloaded to feed and rest for a longer period than forty-eight hours. The board is empowered to make rules and regulations governing the inspection and quarantine of all sheep coming into the State in any manner. The inspector inspecting any such sheep, on which taxes are not paid in this State, as provided for in this act, shall collect (five dollars) \$5 per diem and actual traveling expenses while engaged in inspecting said sheep from the owner or agent in charge of the same. Any sum so collected must be paid into the State treasury, to be credited to the sheep-inspection fund.

Permit for moving scabby sheep. SEC. 14. In no case shall any scabby sheep be removed from one point to another within any district, or from one district to another, without a written permit from the State sheep inspector or one of his deputies.

Governor may prohibit importation of sheep. SEC. 15. Whenever the governor has reason to believe that scab or any other infectious disease has become epidemic among sheep in any locality outside this State, or that conditions exist in such localities that render sheep likely to convey disease, he may thereupon by proclamation designate such locality, and prohibit the driving, shipping, or transportation of sheep from such localities into this State, except under such restrictions as he, after consultation with the board and the State sheep inspector, may deem proper.

Payment of deputy inspectors. SEC. 16. Whenever any deputy inspector files in the office of the State auditor proper vouchers, duly approved by the board, setting forth: 1. The name in full of such deputy inspector. 2. The kind and nature of services rendered. 3. The particular locality where the work was done. 4. The length of time employed. 5. The number of sheep inspected, and the name of the owner or person in charge of such sheep. 6. The disease or diseases treated, and the number treated for each disease, and the length of time of such treatment. 7. The amount claimed for such services. Then, and in such case, the State auditor must draw a warrant in favor of such deputy inspector, payable out of any moneys in the sheep-inspection fund.

Penalties. SEC. 17. Any person who violates any of the provisions of this act, or who disregards any order or direction made by the board in accordance therewith, shall be deemed guilty of a misdemeanor, and shall be punished by a fine not exceeding five hundred dollars (\$500), or by imprisonment not exceeding six months, or by both such fine and imprisonment.

SEC. 18. This act shall take effect upon approval.

Approved March 9, 1903.

VERMONT.

AN ACT Creating a board of cattle commissioners, and to define its powers and duties.

It is hereby enacted by the General Assembly of the State of Vermont:

Governor to appoint board. SECTION 1. The governor shall, in the month of December, A. D. 1902, appoint a State board of cattle commissioners, consisting of three members, who shall be residents of this State, one of whom shall be a practical farmer, who shall be secretary of said board, and the remaining members shall be graduates of some reputable veterinary college. One shall be appointed for one year, one for two years, one for three years. The term of office of each of said members shall commence on the first day of January, A. D. 1903, and the governor shall thereafter annually appoint one member of said board to succeed the member whose term shall expire on the first day of January following. The governor shall also fill all vacancies which shall occur in said board.

Importing animals into State. SEC. 2. The importation of cattle or other domestic animals, except calves under four months old, sheep, and horses not suspected or known to be diseased, into this State is hereby prohibited until the board of cattle commissioners have been notified and the animals shall have been quarantined for such a time as in the judgment of said board the public good requires, and examined by a member of said board and tested with the tuberculin test and pronounced free from tuberculosis or any other contagious disease; but nothing in this section shall be construed to apply to a person transporting cattle through the State on the cars, or to a person living near the State line and owning land in adjoining States and who drives the same cattle to and from the said land to have them examined or tested.

Penalty. SEC. 3. Any person bringing cattle or other domestic animals into this State contrary to the provisions of the preceding section shall be fined fifty dollars (\$50) for each offense, and such importation of each separate animal shall constitute a distinct offense.

Owner may notify board of suspected disease. SEC. 4. Any person who knows or suspects that bovine tuberculosis, or any other contagious disease, exists among his cattle or other domestic animals may, at his discretion, notify the board of cattle commissioners, and the said board shall, as soon as possible, make a thorough physical examination of said animals, and, if it deem necessary to a thorough investigation of the case, may apply the tuberculin test, and if the said animals are found to have a contagious disease, shall cause them to be killed forthwith and the bodies examined and the barns of the owner to be thoroughly disinfected. The expense of slaughtering and disinfecting shall be paid by the owner; and further, the said board of cattle commissioners knowing or hearing of any epidemic contagious disease among animals domestic in the State of Vermont, shall immediately ascertain if any such epidemic disease exists, and if so found shall, in their judgment, quarantine the herds of domestic animals where such epidemic prevails, and shall take such measures for its extermination as, in their judgment, the public good may require; but the foregoing shall not be construed so as to include tuberculosis as an epidemic disease.

Appraisal of slaughtered animals. SEC. 5. The value of all cattle or other domestic animals killed by order of the board of cattle commissioners shall be appraised by two disinterested persons, one to be selected by the member of the board in charge and one by the owner of the cattle, and if these two can not agree upon the amount of the appraisal they shall select a third disinterested person, who, together with them, shall appraise the animals, such appraisal to be made just before killing, and the amount to be as near as possible their actual value, but in no case shall the value of a diseased animal exceed the sum of fifty dollars (\$50). The owner of the animal shall receive eighty per cent of

the appraisal and in addition the hide of the slaughtered animal, the carcass of which shall be buried.

Within sixty days of the date of the slaughter of said animals the amount which the owner is entitled to receive shall be paid by the State to the owner of such animal upon the written order signed by the member of the board in charge and countersigned by the secretary of said board. No indemnity shall be paid to the owner of condemned cattle or other domestic animals that have not been owned or kept in the State for at least six months previous to the discovery of the disease, unless such animal shall have been at the time of importation examined in accordance with the provisions of this act and pronounced free from disease.

Penalty for selling diseased animals. SEC. 6. If any person shall sell or offer to sell any cattle or other domestic animals known by him to be infected with bovine tuberculosis or any other contagious disease, or any disease dangerous to public health, or shall sell or offer to sell any part or parts of such cattle or other domestic animals, except their skins, he shall be fined not more than two hundred dollars (\$200), or be imprisoned not more than one year, or both.

Compensation of members of board. SEC. 7. Each member of the board of cattle commissioners shall receive for his service three dollars (\$3) for each day actually spent in the performance of his duties under the provisions of this act, and shall receive also his actual expenses. All accounts of said board shall be audited by the State auditor and paid by the State.

Prosecutions must be made within six months. SEC. 8. All prosecutions for violations of the provisions of this act shall be commenced within six months from the commission thereof, and not after. Justices of the peace shall have concurrent jurisdiction of all proceedings under this act.

Board to report annually to governor. SEC. 9. The board shall keep a record of its doings and report the same to the governor prior to the fifteenth day of September annually, unless sooner required.

Repealing clause. SEC. 10. Sections 4809 to 4820, inclusive, of the Vermont Statutes, and all other acts or parts of acts inconsistent with this act, are hereby repealed.

SEC. 11. This act shall take effect from its passage.

Approved December 10, 1902.

AN ACT To protect the shippers of cattle from Vermont to Massachusetts, and also butchers slaughtering cattle in Vermont.

It is hereby enacted by the General Assembly of the State of Vermont:

Sale of cattle condemned in Massachusetts. SECTION 1. A person shipping cattle subject to a tuberculin test to any of the three quarantine stations, Watertown, Somerville, or Brighton, or any other city or town in Massachusetts which does not accept a Vermont test, may, if any of said cattle respond to said test, and if the Massachusetts board of cattle commissioners condemn or refuse to accept them, sell such condemned cattle for the highest price obtainable under the Massachusetts regulations, and report in writing to the board of cattle commissioners of Vermont within twenty days from shipment from this State, stating when such cattle were shipped from Vermont, the person or persons from whom purchased, the amount paid for the same, the amount received when sold in Massachusetts, the number of each animal as shown by a tag in the ear of such animal, which shall have been placed there before the animal left the State of Vermont, which must agree with a record kept by the person shipping, and such other information as may be required by said Vermont board of cattle commissioners.

Record from Massachusetts authorities. SEC. 2. Upon the rejection of any cattle by the Massachusetts cattle commissioners the cattle commissioners of Vermont shall request the cattle commissioners of Massachusetts to fill out a certificate showing the number and description of such animal, name of shipper, and cause of rejection, and return the same to the board of cattle commissioners of Vermont.

Compensation to shipper. SEC. 3. After making a report as provided for in section one of this act, to the satisfaction of the Vermont board of cattle commissioners, the shipper shall be entitled to receive eighty per cent of the purchase price, less the amount received for said cattle in Massachusetts, but in no case shall the eighty per cent be reckoned on a sum greater than fifty dollars (\$50).

Butchers to report cases of tuberculosis.

SEC. 4. Any person who slaughters in this State any cattle purchased by him in this State within twenty days previous to such slaughter, and finds the same to be diseased with tuberculosis, may report in writing within five days from time of slaughter to the board of cattle commissioners, stating when and from whom the cattle were bought, price paid, and such other information as may be required by the said board of cattle commissioners, and after making such report such person shall be entitled to receive eighty per cent of the purchase price, but in no case shall the eighty per cent be reckoned on a sum greater than fifty dollars (\$50). Cattle found diseased with tuberculosis under provisions of this section shall be disposed of at the expense of the owner in accordance with such regulations as the cattle commissioners may make, but the owner shall have the hides.

Payment to owners within sixty days.

SEC. 5. Within sixty days of receipt of report by the cattle commissioners, in accordance with sections one and four of this act, the amount which the owner of the condemned cattle is entitled to receive under provisions of those sections shall be paid by the State to the owner of such cattle upon a written order signed by the member of the board in charge and countersigned by the secretary of the board.

Penalty for making false report.

SEC. 6. Any person who knowingly makes a false report to the cattle commissioners in any particular in carrying out the provisions of sections one and four of this act shall be fined not less than one hundred (\$100) or more than two hundred dollars (\$200) for each offense. All prosecutions for violation of the provisions of this act shall be commenced within one year from the commission thereof, and justices of the peace shall have concurrent jurisdiction of all proceedings under this act.

SEC. 7. This act shall take effect January 1, 1903.

Approved December 12, 1902.

WASHINGTON.

AN ACT Prohibiting the importation of horses, cattle, and swine, unless accompanied by a certificate of health and permit from some official veterinarian, excepting animals intended for exhibiting; providing for its enforcement, and fixing a penalty for its violation.

Be it enacted by the Legislature of the State of Washington:

Imported animals must be free from certain diseases.

SECTION 1. That it shall be unlawful to bring into the State of Washington any horses, cattle, or swine for work, feeding, breeding, or dairy purposes: *Provided, however,* That shipments of horses, cattle, and swine may be brought into the State of Washington after said horses, cattle, and swine have been examined and found free from the following contagious diseases: Glanders, farcy, tuberculosis, actinomycosis, rinderpest, foot and mouth diseases, contagious abortion, contagious keratitis, scabies, *maladie du coit*, swine plague, and hog cholera, and a bill of health and a permit given by a State veterinarian, an assistant State veterinarian, a veterinarian of the United States Bureau of Animal Industry, or by a veterinary acting under the order or direction of the live stock sanitary board of any State: *Provided,* That in the case of cattle over six months of age to be used for breeding or dairy purposes, the nonexistence of tuberculosis shall have been determined by the tuberculin test and certified to by the veterinary issuing the above-mentioned certificate of health and permit; the certificate of health and permit given by the above-mentioned veterinarian shall be given in duplicate, the original of which shall be forwarded to the State veterinarian of Washington and the duplicate given to the railroad or transportation company to be attached to the bill of lading for said animals; and no railroad or transportation company—which is meant to include boats, ferries, and bridges—shall accept any such animals for shipment into the State of Washington for work, feeding, breeding, or dairy purposes without the bill of health and permit therein provided for, and no railroad or transportation company shall accept from its connecting lines any animals shipped in violation of this act.

Animals for exhibition are exempt.

SEC. 2. Animals brought into the State for the purpose of exhibition at town, county, district, or State fairs shall not be subject to above regulations: *Provided, however,* That in event of sale being made from such exhibition, the animal sold shall be submitted to examination by the State veterinarian or his authorized deputy and thereby be subject to the rules and regulations governing native Washington cattle.

Penalty. SEC. 3. All railroad, live stock, transportation, and stock yard companies and their employees and all other persons are hereby forbidden to bring horses, cattle, and swine into the State except in compliance with the foregoing regulations, and any violation of the same will constitute a misdemeanor and be punished accordingly.

Approved March 16, 1903.

WISCONSIN.

AN ACT To amend section 3, chapter 440, of the laws of Wisconsin of 1901, relating to the slaughter and appraisement of animals.

The People of the State of Wisconsin, represented in Senate and Assembly, do enact as follows:

Amendment to law of 1901. SECTION 1. Section 3 of chapter 440 of the laws of Wisconsin of 1901 is hereby amended by inserting after the words "town board," in the 23rd line thereof, "or the State veterinarian or his assistant, or any member of the live stock sanitary board," so that said section, when amended, shall read as follows: Section 3. Whenever the owner shall not exercise option and it shall be deemed necessary by the board to slaughter diseased

Slaughter and appraisement of animals. animals, written notice shall be given to the owner, his agent, or the person in charge of such animals, and to a justice of the peace in the county in which the animals may be, of the purpose to order the slaughter thereof, giving the number and description of the animals, and the name of the owner, if known. Such notice shall be entered on the docket of such justice, who shall immediately thereafter summon such owner, agent, or possessor, and also three disinterested citizens of the county, not residents of the immediate neighborhood in which such animals are owned or kept, to appraise the value thereof. Such appraisers shall, before entering upon the discharge of their duties, be sworn by such justice to make a true appraisement, without prejudice or favor, of the value of such animals, and they shall certify in their return that they have seen the appraised animals slaughtered. In making the appraisement of diseased animals, the appraisers shall determine their value in the condition in which they are found at the time of appraisement; but the appraised value of no single animal shall exceed fifty dollars (\$50). If such appraised animals are slaughtered, said slaughter shall be made under the direction of the local health officer, or the chairman of the town board, or the State veterinarian, or his assistant, or any member of the live stock sanitary board. The owner of slaughtered animals shall receive no compensation for the same until the live stock sanitary board is satisfied that the infected premises have been disinfected in such a manner as to prevent the further spread of disease.

SEC. 2. This act shall take effect and be in force from and after its passage and publication.

Approved March 21, 1903.

AN ACT Governing the importation of branded or range western horses.

The People of the State of Wisconsin, represented in Senate and Assembly, do enact as follows:

Range horses entering State must be certified by an inspector. SECTION 1. No person shall ship or bring into the State of Wisconsin branded or range western horses unless the same are accompanied by a certificate of inspection made by a duly qualified veterinary surgeon who is a graduate of a recognized veterinary college in the United States, Canada, or Europe, which certificate shall show that at the time of said inspection the horses so inspected were free from glanders and farcy, infectious mange, or any other disease of a contagious malignant character. This inspection shall be made at the last loading place before entering the State, except in the case where animals are driven into the State, when the examination shall be made at the first stopping place within the State.

Method of preparing certificates. SEC. 2. The inspector shall prepare certificates in triplicate, one to be given to the shipper, one to the transportation company hauling said horses, and one to be forwarded immediately to the State veterinarian at Madison, Wisconsin. Said certificate shall state that said inspector has carefully examined all such animals for glanders or farcy, infectious mange, or any other disease of a contagious malignant character,

and has found the same to be entirely free from all such diseases. The certificates shall further state the number of the car or cars containing such animals, the initial letters of the railway owning the car or cars, the number of horses in each car, the name of the shipper, and the destination of the car or cars, and the name of the railroad hauling such car or cars, and shall be duly signed by and sworn to before a notary public or a justice of the peace by the person making such inspection. The expenses of such inspection and certificate shall be paid by the owner or shipper of said horses.

Horses entering without certificate must be quarantined.

his possession a certificate as provided in section one of this act, showing all such horses to be free from such diseases, the local health officer shall immediately quarantine the yards containing such animals and at once notify the State veterinarian, who shall immediately authorize an examination of said animals by a competent and duly qualified veterinary surgeon. If, after such examination, the said animals shall be found to be free from disease, the same shall be released upon payment of the expenses of such quarantine and examination as herein provided. If, upon such examination, said animals, or any of them, shall be found diseased with glanders or farcy, infectious mange, or any other disease of a contagious malignant character, then and in such event the Wisconsin live stock sanitary board shall quarantine such animals or cause the same to be slaughtered, as is provided in chapter 440 of the laws of Wisconsin of 1901, except that in no event shall the owner or shipper of such animals receive any indemnity in case such animals are killed under the direction of said board. The expenses of such quarantine, examination of said animals, and subsequent disinfection of quarantined yards where disease is found present, shall be paid by the owner or shipper of said horses.

Board may examine suspected horses.

Sec. 4. In case any such horses shall be brought into this State after an inspection thereof as provided in section one of this act, and the owner or shipper thereof shall have a certificate of inspection as therein provided for, showing the said horses to be free from any such disease, and it shall come to the knowledge of the Wisconsin live stock sanitary board that said horses are suspected of being affected by diseases as specified in this act, then it shall be the duty of the Wisconsin live stock sanitary board to fully and carefully examine said horses, and if it shall be found and determined by the said board that the said horses were diseased at the time they were brought into this State, then the said board shall proceed to dispose of said horses as provided in chapter 440 of the general laws of 1901. But if the same are killed as therein provided no indemnity shall be paid to the owner of said horses, if the said disease existed at the time the horses were brought into this State, and the determination of the said Wisconsin live stock sanitary board shall be prima facie evidence upon that question.

No inspection necessary for temporary stoppages.

Sec. 5. In case horses billed for points beyond the State are unloaded in the State for feeding purposes for a period not exceeding forty-eight hours, it shall not be necessary to make such inspection as above stated.

Penalty for unloading horses not certified.

Sec. 6. Transportation companies unloading branded or western range horses in this State, which are not accompanied by a certificate of inspection as above designated, except as provided in section 5, shall be subject to a penalty of not less than one hundred dollars (\$100) nor more than two hundred dollars (\$200) for each car so unloaded in this State, such penalty to be recovered at the suit of the State, brought by the attorney-general.

Penalty for driving uncertified horses into State.

Sec. 7. Any person or persons bringing into this State branded or western range horses that are not accompanied by a certificate of inspection as hereinbefore provided shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be punished by a fine of not less than one hundred dollars (\$100) nor more than two hundred dollars (\$200).

Sec. 8. This act shall take effect and be in force from and after its passage and publication.

Approved May 6, 1903.

[Continued from second page of cover.]

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Dr. W. B. Lincoln, Union Stock Yards, Nashville, Tenn.
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Dr. J. C. Milnes, care The Rath Packing Co., Waterloo, Iowa.
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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF ANIMAL INDUSTRY—BULLETIN No. 55.

D. E. SALMON, D. V. M., CHIEF OF BUREAU.

STATISTICS OF THE DAIRY.

COMPILED FROM THE UNITED STATES CENSUS FOR 1900,
AND FROM OTHER RELIABLE SOURCES,
WITH EXPLANATORY NOTES,

BY

HENRY E. ALVORD, C. E.,
Chief of the Dairy Division.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1903.

LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., March 1, 1903.

SIR: I have the honor to transmit herewith for publication, as Bulletin No. 55 of this Bureau, a compilation by Maj. Henry E. Alvord, Chief of the Dairy Division, of the principal statistics relating to the dairy industry of this and other countries. The development and magnitude of this branch of agriculture are thus shown better than by any available publication, and the information is such as is needed, not only by dairymen, but by the many other persons whose business is closely related to the dairy industry.

The illustrations, which consist of five diagrams and four maps, are necessary to an understanding of the text.

Very respectfully,

D. E. SALMON,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY, DAIRY DIVISION,
Washington, D. C., February 25, 1903.

SIR: I have the honor to submit herewith for publication a compilation of the principal statistics relating to the dairy industry in the United States, together with some similar data from other countries.

A part of the figures thus brought together are easily found, but, on the other hand, many of them are inaccessible to people generally. It is believed that the collection as presented will prove interesting and useful to many persons connected with dairying and form a suitable complement to other publications prepared by this division.

The tables are preceded by a discussion of the subject and accompanied by maps and diagrams which serve to illustrate parts of the text.

Yours, respectfully,

HENRY E. ALVORD,
Chief of Dairy Division.

Dr. D. E. SALMON,
Chief of Bureau of Animal Industry.

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STATISTICS OF THE DAIRY.

By HENRY E. ALVORD, G. E.,
Chief of Dairy Division, Bureau of Animal Industry.

A STATISTICAL REVIEW OF THE CENSUS RETURNS.

The latest available statistics of the dairy industry in the United States, considered as a whole, are mainly included in the Twelfth Census. For a comprehensive study of the subject one must bring together some tables in the volume for agriculture and others from that for manufactures. Unless acquainted with the matter, there is the liability of omitting items of importance. There are, in addition, some reliable and interesting data more recent than the United States Census, obtainable from State authorities, although relating to a comparatively few States; and there is also statistical information concerning the dairy in foreign countries which has some influence upon the industry in the United States and which is useful for purposes of comparison.

All of these statistical data have been brought together and will be found in the following pages, arranged in a manner convenient for practical use. The figures for earlier decades are given in connection with the latest, and some general farm statistics are added which have a bearing upon the dairy industry or show its position with relation to other branches of agriculture.

It should be noted that in census statistics all enumerations of persons, farms, animals, etc., are for June of the year stated, while the figures for products of all kinds, although often mentioned in the same connection and sometimes as being for the same year, actually represent the returns for the agricultural year next preceding.

DAIRY FARMS.

The Twelfth Census reports that in the year 1900 there were 5,739,657 farms in the United States, and of these 4,514,210 had dairy cows. Where a farm was found upon which at least 40 per cent of the value of annual products was from dairy products, it was classified as a dairy farm. Of these there were 357,578, or 6.2 per cent, of the total

number, and the average size of these dairy farms was 121 acres. One-sixth of the number ranged from 20 to 50 acres; one-fourth of all, 50 to 100 acres; and rather more than one-fourth, 100 to 175 acres. There were 174,910 "dairy farms" in the North Atlantic States; 108,408 in the North Central Division; 34,940 in the South Central; 27,620 in the Western; 11,671 in the South Atlantic Division, and 34 in Alaska and Hawaii.

DAIRY COWS AND OTHER NEAT CATTLE.

All dairy statistics must be based upon the number of cows contributing to the milk supply. The activity of dairying and the comparative importance of the industry in any country can be primarily determined by the ratio which the number of dairy cows owned bears to the total of other neat cattle. But the reliability of this test depends upon the accuracy with which the different kinds of cattle have been enumerated and classified. The next significant indication is the ratio of cows to inhabitants. The "milch cows" of the United States were first counted by the Sixth Census (1840) and reported as being 4,837,043 in number, or 283 for every 1,000 of the population. The enumeration has been made decennially since that time, with probable varying degrees of accuracy. The ratio of cows to 1,000 people has appeared to be fairly constant, as follows: In 1840, 283; 1850, 275; 1860, 273; 1870, 232; 1880, 248; 1890, 264; 1900, 237; average of the ratios, 259.

The variations are easily accounted for. The sudden decrease from 1860 to 1870 resulted from losses incident to the Civil War, and it required another decade to restore the normal ratio. The ratios in 1890 and 1900, when compared with those of 1850 and 1860, signify improved productiveness of the average cow, especially so as there is reason to regard the number for 1880 as too great; and explanations which soon follow indicate that the same applies to 1890. The average of the stated ratios for sixty years (259 cows) is therefore probably too large. Past errors in this matter have been mainly due to the uncertainty of deciding what was a "milch cow." This term has been too broad and indefinite, and has led to including many under this head which were in no sense dairy animals. It is easily understood that the average dairy cow of the country has been steadily gaining in yield of milk, and, although the consumption of dairy products per capita has doubtless somewhat increased also, it nevertheless requires a less number of cows to supply a thousand people now than was necessary thirty, forty, or fifty years ago.

The enumeration of cows for the Twelfth Census has been made with greater care than ever before. The farm schedule called for "cows kept for milk," and it is believed that this secured practically all animals on farms that could fairly be regarded as dairy cows and

excluded those properly belonging in other classes. The result was that 17,139,674 cows over 2 years old were reported as kept for milk on 4,514,210 different farms. (It is interesting to note that 1,225,447 census "farms," or over 21 per cent of the total number, reported no cows kept for milk.) The cows not on farms or ranges, or what may be called the "town cows," were counted in 1900 for the first time and, surprisingly, found to number 973,033, or $5\frac{1}{2}$ per cent of our entire milking stock. The whole number of what may be considered dairy cows in the year 1900 was therefore 18,112,707. This is believed to be more nearly accurate than any previous enumeration of this class of animals in the United States. There are numerous pieces of external evidence, which can not be quoted here, which support the census results in this particular. (And yet the census authorities believe that a considerable number of cows escaped the count.) These figures should be accepted as the basis of all other dairy statistics until replaced by later and equally satisfactory data.

The probable error in accepting as actual dairy cows the number of "milch cows" reported by the census of 1890 may be shown by a few examples: It is known to be a fact that the dairy cows form at the present time a larger proportion of the total cattle owned, in most of the States, than was the case ten or twenty years ago. This is especially true throughout the East, where dairy cows have notably increased and other cattle have diminished. But the tables of the census for 1890 show the milch cows to be a greater percentage of the total cattle in all of the New England and Middle States, New Hampshire alone excepted, than the dairy cows are shown to be by the census of 1900. In Massachusetts the milch cows constituted 67 per cent of the total cattle in 1890, and the "cows kept for milk" were only 65 per cent of the total cattle in 1900; yet authorities agree that the dairy cows of that State have increased in both actual number and proportion. For New York these percentages are 68 for 1890 and 58 for 1900; in New Jersey, 76 and 66, respectively. The comparison is more striking, however, in States known to have large numbers of beef cattle. In the two Dakotas the milch cows in 1890 were reported as 31 per cent of the total cattle, but in 1900 the cows kept for milk were found to be 18 per cent only of all cattle. In Florida these percentages were, respectively, 23 and 10; in Colorado, 17 and 7; and in Texas, 16 and 9. Texas had 1,000,439 milch cows in 1890, according to the census of that year, whereas only 861,023 were enumerated in 1900; yet the milk product of the State is reported as more than doubled during the decade, and it is a commonly known fact that the dairy cows of Texas have increased greatly in late years; the only explanation is that probably thousands of Texan breeding cattle were erroneously classed as milch cows in the Eleventh Census. Taking the totals for the United States for like comparison, the animals reported as milch cows in 1890

constituted 32.15 per cent of the total cattle on farms and ranges, while in 1900, when we have ample reason for believing the actual percentage of dairy cows to be greater, the "cows kept for milk" constitute 25.27 per cent of all cattle on farms and ranges and only 26.08 per cent of total cattle in all inclosures.

These evidences of error in the enumeration of dairy cows for 1890 render quite unreliable the total number as then reported. The thousands of cows belonging to the beef classes that were counted as dairy animals were in some measure offset by the thousands of town cows and others not on farms, and so not counted at all. But both of these factors are too uncertain to estimate.

It is useless, therefore, to make any further close comparison of the cattle statistics of the Twelfth Census with those of the Eleventh, although the figures for both are placed in the tables on later pages.

The classification for 1900 not only succeeded better in separating the real milch cows from "other cattle," but enumerated the latter in seven classes, by age and sex, as follows: (1) Cows and heifers not kept for milk, 2 years old and over; (2) heifers 1 and under 2 years; (3) calves under 1 year; (4) steers 1 and under 2 years; (5) steers 2 and under 3 years; (6) steers 3 years and over; (7) bulls 1 year and over. The three classes first named and the last included animals of dairy breeding, and the cattle classes were completed by (8) "cows kept for milk, 2 years old and over."

The following summary of all cattle is arranged from the dairy standpoint:

TABLE I.—*Dairy cows and other neat cattle in the United States in 1900.*

Classes.	Number on farms or ranges.	Number not on farms or ranges.	Total.
Cows kept for milk.....	17, 139, 674	973, 033	18, 112, 707
Cows not kept for milk.....	11, 592, 142	75, 767	11, 667, 909
Heifers (yearlings).....	7, 183, 916	79, 517	7, 263, 433
Calves, steers, and bulls.....	31, 906, 604	488, 105	32, 394, 709
Aggregate	67, 822, 336	1, 616, 422	69, 438, 758

There were thus 37,044,049 cows and heifers of all kinds 1 year old and over in this country at the last enumeration, and 48.9 per cent of this number was dairy cows already "in profit" "kept for milk." Of all the cows 2 years old and over, 100 appear to have been for dairy purposes for every 64 kept for breeding and beef.

The geographical distribution of the dairy industry is indicated by these ratios: In the North Atlantic States there were 780 dairy cows to 48 other cows, or 16 to 1; in the South Central Division, 326 dairy cows to 490 cows for breeding and beef, or 1 to 1.5; and in the Western Division, only 207 dairy cows to 603 others, or 1 to 3. "Of the

37,044,049 cows and heifers over 1 year old, 15,580,120, or 42.1 per cent, were found in the North Central Division (of States); 9,504,190, or 25.7 per cent, in the South Central; 4,698,061, or 12.7 per cent, in the North Atlantic; 4,649,595, or 12.6 per cent, in the Western; 2,565,661, or 6.9 per cent, in the South Atlantic Division; and 46,422, or 0.1 per cent, in Hawaii and Alaska." For every farm reporting, there were 14.3 head of neat cattle of all classes and 3.6 cows kept for milk.

The census for 1900 reports the aggregate value of neat cattle in the country as \$1,517,602,351, rather more than one-third of which is assigned to the dairy cows.

PUREBRED CATTLE AND "STATISTICS OF QUALITY."

The following quotations are from the general discussion of neat cattle in the first agricultural volume of the census of 1900:

The Twelfth Census endeavored to secure statistics of the number of pure-blooded cattle and the number of those of special breeds. The attempt, so far as it depended upon the reports of the enumerators, was not successful.

Some attention has been given to breeding cows for dairy purposes only, and with this object in view importations have been made of the Jerseys and Alderneys. There are now many fine herds of both breeds. As the great majority of American farmers keep cattle for beef as well as for milk, they prefer the Herefords and Polled Angus, which are valuable for both purposes.

A statement is made later that, based upon correspondence, the census authorities estimated that in 1900 there were 700,000 "pure-bloods of all kinds" among the cattle of the United States, or about 1 per cent of the total number. The Eleventh Census did more work in this respect. Under the title, "Statistics of quality," it was reported that in the year 1890, taking the country as a whole, 0.99 per cent of neat cattle on farms were purebred, and 16.08 per cent were grades having one-half or more of improved blood. This left 82.93 per cent of common, or native, stock, including grades less than one-half pureblood. In the North Atlantic States there were then 1.77 per cent of purebred cattle; in the North Central Division, 1.21 per cent; in the South Atlantic, 0.73 per cent; in the South Central, 0.46 per cent; and in the Western Division, 0.52 per cent of the purebred. The highest percentage of grades was then reported in the North Central Division, being 22.21, or a total of 23.42 per cent of all the cattle having one-half or more of improved blood.

Assuming these last returns to have been reasonably correct, there must be now much more than 1 per cent of the neat cattle of the country of the different pure breeds. In a recent review of this subject the writer estimated that, so far as the dairy cattle of the country are concerned, about 2 per cent are now purebred and nearly if not quite half of all the cows are of improved blood.

DAIRY COWS ON FARMS AND RANGES.

The Twelfth Census applies this term to all "cows kept for milk 2 years old or over." Of the total number, already given as 17,139,674, nearly one-half, or 49.5 per cent, were found in the North Central Division of States. In the North Atlantic Division there were 20.4 per cent; in the South Central, 16.9 per cent; in the South Atlantic, 8.1 per cent; and in the Western Division, 5.1 per cent of the total.

The distribution of these cows upon farms (4,514,210) classified by tenure of the farms was as follows: On farms of owners, 10,459,262; part owners, 1,734,648; owners and tenants, 207,162; managers, 295,794; cash tenants, 1,823,713, and share tenants, 2,619,095. There were 579,908 dairy cows upon 348,970 farms of colored farmers. As to distribution on farms of specified areas there was an average of 170 cows to every 100 farms of 3 to 20 acres in area, and this average gradually increased, with much regularity through succeeding groups, to 950 cows for every 100 farms of more than 1,000 acres each.

The foregoing statistics indicate the character of the distribution of the dairy industry in this country, geographically and otherwise. The census gives tables of the number of dairy cows on farms in the several States and Territories, and also by counties therein. The ten most important dairy States rated by the number of cows on farms, June 1, 1900, were the following: New York, 1,501,608; Iowa, 1,423,648; Illinois, 1,007,664; Wisconsin, 998,397; Pennsylvania, 943,773; Texas, 861,023; Ohio, 818,239; Missouri, 765,386; Minnesota, 753,632, and Kansas, 676,456. The only other States having more than half a million dairy cows on farms were Michigan and Nebraska.

DAIRY COWS NOT ON FARMS OR RANGES.

As stated already, this enumeration was made for the first time in the year 1900. All domestic animals in inclosures but not on farms or ranges were included. There were 801,817 different "inclosures" reporting cattle, and it is estimated that 775,000 of these contained dairy cows, which were found to be 973,033 in number. None of the large dairy herds or stables of cities and towns were included, however, because wherever 3 or more cows were reported in one place the matter was specially investigated; and, if it was found that the animals required the constant services of one or more persons, the establishment was treated as a farm. The cows of city dairies in general are therefore included among those tabulated as on farms. Consequently the cows in this "not-on-farms" class were almost all those of owners who kept 1, 2, or 3, and primarily, in most cases, for their own use. They were located, as a rule, in villages, small towns, and the suburbs of larger places rather than in cities. They may be appropriately

called "town cows" as distinct from farm cows, and they constitute 5.4 per cent of all the milking stock of the country.

It is interesting to note that the cows of this class were not found in greatest numbers coincident with the most dense population. Thus nearly one-half of all (45 per cent) were in the North Central division of States, 21 per cent in the South Central, 17.4 per cent in the North Atlantic, 9.6 per cent in the South Atlantic, and 7 per cent in the Western. This distribution follows very closely that of cows on farms. The Twelfth Census gives tables showing the whole number of dairy cows found in 166 named cities of over 25,000 inhabitants, and the number of such cows to 1,000 inhabitants in each of the same cities. From these tables it appears that in 43 cities of 100,000 or more inhabitants each there were 88,600 dairy cows; in 40 cities of 50,000 or more inhabitants, 26,978 cows; and in 83 cities of over 25,000 and less than 50,000 inhabitants, 41,152 cows. There were thus a much greater proportion of town cows in the smaller cities. In the 166 cities named, containing a total population of about 20,000,000, there were 156,730 dairy cows over 2 years old, but of this number 90,146 were tabulated as "on farms," according to the plan adopted, leaving only 66,584 of scattered ownership, or "not on farms." Less than 7 per cent of the town cows was therefore located in cities of more than 25,000 inhabitants. It is thereby again shown that these cows were nearly all kept in the smaller municipalities and in semirural communities.

The States having the greatest number of town cows were Pennsylvania, 78,301; Texas, 63,876; Illinois, 56,827; Iowa, 56,028; Ohio, 50,593; and Missouri, 49,192. The States of Michigan, Kansas, Indiana, New York, Minnesota, and Wisconsin each had between 34,000 and 40,000 of this class of animals.

Greater New York kept 11,577 cows within its limits in 1900, and other cities as follows: St. Louis, 9,481; New Orleans, 6,340; Chicago, 5,901; Philadelphia, 4,981. The only others having as many as 4,000 were St. Paul and Minneapolis. Of the other large cities, Baltimore reported 1,600 and Boston 1,151.

The cities having the greatest number of dairy cows to 100,000 inhabitants (or in that proportion) were as follows: Sioux City, Iowa, 6,850 (or, actually, 2,268 cows to 33,111 people); Council Bluffs, Iowa, 5,058; Des Moines, Iowa, 4,458; and Superior, Wis., 4,053. The cities of Newton, Mass.; Fort Worth and Dallas, Tex.; Joplin, Mo.; Haverhill and Taunton, Mass.; Topeka, Kans.; Little Rock, Ark.; Montgomery, Ala.; and Lincoln, Nebr., had, in the order named, from 3,600 to 3,000 cows to 100,000 inhabitants, or at that rate. Among the great cities, the highest rate was 1,648 in St. Louis and the lowest was 205 in Boston. In New York, Chicago, Philadelphia,

and Baltimore the rate was between 300 and 400 dairy cows to 100,000 population.

The value of these town cows is not given in the census, nor the quantity and value of their products; but there can be no doubt that the cows of this class were of decidedly better quality and higher value than the average dairy cows on farms, and their products were correspondingly greater.

TOTAL DAIRY COWS—THEIR DISTRIBUTION, VALUE, AND PRODUCTS.

The total number of dairy cows in the several States and Territories, including those on farms and ranges and also those in barns and inclosures elsewhere, will be found in Table XIII, page 59. The position of the States as to total number of dairy cows "in all inclosures" is practically the same as already stated for cows on farms. The only ones having over 1,000,000 cows kept for milk are New York, Iowa, Illinois, and Wisconsin.

The total number of cows in a State does not, however, give as good an idea of the prominence of dairy interest as the density of the cow population (so to speak) and its relation to the number of inhabitants. New York stands first in this respect also, having 32.30 cows per square mile of land area, and in this State are three counties where the cows considerably exceed the people in number: Delaware County has 76,384 dairy cows, or 1,646 per 1,000 inhabitants; Chenango County has 53,751 cows, or 1,470 per 1,000 inhabitants; and St. Lawrence County has 105,440 cows (the greatest number of any county in the Union), or 1,184 per 1,000 of its population. The comparatively small State of Vermont comes next in number of cows per square mile, with 30.28, and there are also three counties in this State—Addison, Franklin, and Orleans—having from 1,100 to 1,250 cows to every 1,000 inhabitants. Connecticut comes next with 27.35 cows per square mile; then Iowa with 26.67 cows per square mile, and the counties of Delaware, Jones, and Kossuth, with 24,000 to 26,000 cows each, being 1,100 to almost 1,400 per 1,000 inhabitants. Other States having more than 20 dairy cows per square mile are the following: Massachusetts, 24.81; Rhode Island, 23.77; Pennsylvania, 22.72; New Jersey, 22.30; Ohio, 21.32. Five other States have over 15 cows per square mile. In ten other counties of the Union the dairy cows exceed the population, six of these being in Wisconsin, two in Minnesota, and one each in Illinois and Ohio. McHenry County, Ill., exceeds all others in this particular, having 51,419 dairy cows, and the remarkable ratio of 1,728 cows to 1,000 inhabitants.

The enumeration of all cattle by classes of age, sex, and utility, as described, enabled an estimate to be made of the average longevity of cows. The census considers a little less than 7 years to be the life of dairy cows, approximately, in the North Atlantic States, giving not quite 5 years as the average period of profit. In the other geographic

divisions of the country these averages appear to be nearly one year less.

The Twelfth Census places the average value of the dairy cows in the United States in 1900 at \$29.68. This makes the total value \$537,624,750. The highest value per head, \$35.43, is assigned to the Western Division, and the lowest, or \$21.97, to the South Atlantic Division. But in this estimate the town cows are rated no higher than those on farms. This is believed to be an undervaluation for cows in that class, so that the average for the year 1900 can safely be placed at something over \$30 per head.

Although, for the reasons stated, close comparisons should not be made between the dairy statistics of the Twelfth Census and those preceding, it is convenient to do so, in a general way, in some instances. An increase of about 1,500,000 cows seems to have occurred in the United States during the last decade, and this increase appears to have been quite evenly distributed over the country. Gains have occurred in all the five divisions in which the States are grouped for census purposes, but none especially marked, although the greatest has been in the eleven States of the Western division. The next largest increase is in the North Atlantic division, where demand for the combined dairy products greatly exceeds local production. In every one of the nine North Atlantic States, excepting perhaps New Jersey, there are more cows kept for milk than ever before. The increase in Vermont is believed to have been 20 per cent.

Comparisons between the dairy products reported by the Twelfth Census and the Eleventh should also be made with large allowances, if at all. There can be no doubt, however, of the material improvement in the dairy quality of cows kept for milk, and consequently in proportional aggregate production. The Eleventh Census gave the average annual milk product per cow as 315.4 gallons, the Twelfth Census reports the product as 424 gallons. This very remarkable gain is apparent rather than real. The average yield of milk per cow in 1890 must have been considerably greater than reported (so many animals were counted as milch cows which actually contributed nothing to the milk supply), and it seems certain that the figures for 1900 are too high.

Whatever the latter error may be, it is doubtless distributed quite evenly, so that the average annual yield per cow as given in the agricultural returns of the last census for different parts of the country are comparable. These show the relative productiveness of the cows in different sections in a very striking manner. The average for the cows of the North Atlantic States is given as 523 gallons; for the North Central Division, 425 gallons; for the Western Division, 418 gallons; for the South Atlantic Division (nine States), 356 gallons, and for the South Central Division (eight States), 336 gallons. The highest

annual yield returned is from the 1,251 cows on the 169 "farms" in the District of Columbia, being 680 gallons per cow. The States showing the best returns per cow are the following: Maine, 574 gallons; Massachusetts, 572; Rhode Island, 546; Connecticut, 545; New Hampshire, 528; Vermont, 526; Ohio, 520; Pennsylvania, 516, and New York, 515. Among the big dairy States of the North Central Division, the average yield in Wisconsin is placed at 473 gallons; in Illinois, 454; in Minnesota, 403, and in Iowa, 376. One of the greatest contrasts in this particular is shown by two States having a nearly equal number of cows: Arkansas has 312,577 cows on farms, averaging 351 gallons of milk and returning a total farm value for its dairy products of \$6,912,459. California has 307,245 cows on farms, averaging 500 gallons of milk, and its total dairy products were valued at \$12,128,471, or nearly twice as much as the other State, although the latter had 5,332 more cows.

The figures in the last paragraph are taken from those showing the total milk produced on 4,514,210 farms, according to the tables of the Twelfth Census. The "town cows" are not taken into consideration here. Relatively, the rates of production appear to be very nearly correct, although some errors are evident. New York is unquestionably too low; it should rank with the New England States in milk yield per cow. The Ohio average can not actually be higher than that of Illinois and is probably lower. Minnesota should stand next to Wisconsin. The evidence is abundant in support of these changes, although it can not be given here. But nearly all these census averages of yield per cow for farm cows are believed to be somewhat too large. They are not sustained by the other dairy statistics of the census nor by the numerous disconnected pieces of evidence which are available for verifying or testing the census returns. Instead of 424 gallons, as shown by the census, it is believed to be much nearer the truth to place the average annual yield of milk at 3,600 pounds per cow, which is a little over 418 gallons. This seems an immaterial reduction, but it makes quite a difference in the aggregate production for the 17,000,000 cows on farms.

As already stated, the milk and derivative products of cows "not on farms," but "kept for milk," were not obtained and reported by the Twelfth Census. An estimate of this production must therefore be made, as it will not do to ignore so important a factor as 6 per cent or more of all milk produced in the country. Whether right or wrong, the annual average yield per cow as given by the last census will be accepted and used as the basis of computations until more satisfactory data are available. This is 424 gallons per cow for those on farms. The "town cows" may safely be estimated, upon this basis, as producing 475 gallons per head. This is probably as much below the truth as the yield assigned to farm cows is above it. A few

examples may be given: The cows reported above for the District of Columbia as having an annual yield of 680 gallons each were the herds owned by public institutions and by milk-supply dairies. They were all practically "town cows" for market milk, and the 558 cows in the District not on farms were doubtless of the same kind and equally good, producing 600 or 700 gallons of milk each per year. The county of Richmond, N. Y., is Staten Island, a suburb of the metropolis. This county is credited with 1,444 cows upon 212 "farms," producing an average of 604 gallons of milk per cow. There were in the county 526 other cows, undoubtedly of equal dairy merit. More than three-quarters of the milk product reported was sold. The cows of this county were thus practically all "town cows" for market milk, producing annually over 600 gallons per head. Suffolk County, Mass., is covered by the city of Boston. The census reports 887 cows on 93 "farms" within the county, producing milk at the rate of 510 gallons yearly per cow. There were 509 other dairy cows "not on farms" in this county. Substantially all the milk produced was sold. All were "town cows" for market milk, producing over 500 gallons per head per year. (The probability is that the average yield of these cows was actually more.) The city and county of San Francisco are practically one. There were 5,005 cows reported as "on farms" in the county (and city), producing milk reported at nearly 4,000,000 gallons; practically all of this was sold. There were 608 other dairy cows. The average production reported for all these "town cows" was almost 800 gallons per year, while the average for the entire State is given as 500 gallons.

Other examples might be given to show that the dairy cows "not on farms" were in all cases much larger producers than those on farms, and were very generally not only "kept for milk," but for milk to be sold. Butter may have been made from some of them; in the main, however, their milk was used or sold, constituting a very large share of the total supply of market milk. It would be quite conservative to credit this important class of dairy cows with 500 gallons each per annum, but, as an offset to the probable excessive rate of 424 gallons per cow on farms, the rate of 475 will be estimated for cows not on farms and used for all subsequent computations in these pages.

The safest way to avoid duplication and conflict in considering the total annual dairy production of the country is to estimate the number of cows and the yield of milk necessary for the different products. The following arrangement answers that purpose for the year 1900:

	Cows.
For butter, at 154 pounds per year per cow	9,700,000
For cheese, at 368 pounds per year per cow	800,000
For condensed milk, at 912 pounds per year per cow	200,000
For milk consumed, at 430 gallons per year per cow	7,412,707
Total number of cows	18,112,707

This arbitrary arrangement of cows to the different branches of dairy production is based upon the published summaries of the Twelfth Census. Yet a smaller number of cows are thus assigned to butter and cheese production than was done ten years earlier, when these products were also much less. It might be more accurate to assume a lower rate of butter and cheese product and increase the number of "butter cows" and "cheese cows;" the number remaining for milk consumed would then be less, as it doubtless should be.

THE AGGREGATE MILK PRODUCTION AND ITS DISPOSITION IN THE
UNITED STATES.

The agricultural tables of the Twelfth Census give the total quantity of milk produced on farms in this country, during the year 1899, as 7,266,392,674 gallons, or, in round numbers, 62,500,000,000 pounds. This was the product of 17,139,674 cows, reported from 4,514,210 farms, or an average of 424 gallons (3,650 pounds) per year per cow. As already noted, this statement of the milk product is believed to be too large. But these are the figures which will be generally quoted and referred to for some years to come, so that they may as well be considered as they stand. Of the total quantity, 49.7 per cent, or nearly one-half, was reported from the North Central Division and 25.1 per cent, or half the remainder, from the North Atlantic States.

To the product of the farm cows must be added that of nearly 1,000,000 town cows. Estimated as heretofore and for the reasons stated, as 475 gallons (or about 4,000 pounds) per cow, the annual product of this class of cows will be 462,190,675 gallons, or 3,900,000,000 pounds, which is more than one-sixteenth of the gross yield of the farm cows. There is no basis for determining the uses to which this great quantity of milk was applied. Most of it was doubtless consumed in its natural state. The total being regarded as market milk, there was enough to supply three or four times as many persons, at the average rate, as were included in the families of the owners of these cows not on farms. An indefinite portion of this milk must have been contributed, however, to the materials reported as received by the butter, cheese, and condensed-milk factories, and applied to making butter for the home use of the cow owners.

Altogether the milk produced in the United States during the year 1899 is thus placed at 7,728,583,349 gallons, or rather more than 66,000,000,000 pounds, being an annual supply of 101.3 gallons for every man, woman, and child in the country.

Accepting this great aggregate as possible, if not probable, the interesting question arises, How was all of this cows' milk used or disposed of? The census statistics furnish no satisfactory answer; the data obtained is interesting and suggestive, but it is plainly neither accurate nor complete. Effort was made to obtain information as to

the disposition of milk on farms. The butter and cheese made thereon was reported and also the milk and cream sold. The gross sales of milk were returned as 2,134,915,342 gallons, and of cream 20,768,662 gallons, being equivalent to 114,227,641 gallons of additional milk. A table is presented in the agricultural volume of the census (Table CLXVII, Vol. V, p. clxxvi) which is intended to show how the milk produced on farms was utilized. Besides the portion above stated as sold, estimates are given of the quantity converted into butter and cheese, and a conclusion reached as to the milk consumed on farms in ways unreported. In doing this, however, allowances were made at least 10 per cent too great for the milk made into cheese and 25 per cent too great for milk made into butter.^a By correcting these manifest overestimates of the application of milk to butter and cheese made on farms, it is found that, instead of 1,244,857,710 gallons of milk consumed on farms, or 276 gallons per year for every farm reporting, the milk product of farms left unaccounted for is 1,402,644,302 gallons, or 12,062,740,994 pounds, being 310.7 gallons (or 2,672 pounds) annually per farm.

When, in addition to this, the enormous farm supplies of skim milk and buttermilk are considered, it is evident that some disposition other than consumption by human beings must be accepted as an explanation. One of three things must be true: The total milk product of cows on farms must have been considerably less, or the quantity of milk and cream sold from farms must have been much greater than reported, or some other use must have been made on farms of a large share of the milk produced. The sales of milk and cream are probably the most accurate of the farm dairy statistics. In many cases these facts are matters of record. Next in reliability are the sales of butter and cheese from farms; less reliable are the totals of these articles made on farms. Most doubtful of all is the annual milk product, especially when measured in gallons and estimated in June, 1900, for the twelve months ended with the December previous. But still, accepting these returns, a rational disposition must be sought for much of the milk reported produced. The census barely suggests an explanation by a single sentence: "In many reports, particularly from the North Central States, mention was made of the fact that some milk reported was fed to calves raised for veal." Before this sentence was written the writer proposed, in a paper published on this subject, to assign a definite and considerable portion of all milk reported produced on farms to the

^aThe census estimates 3.5 gallons of milk, or a little over 30 pounds, per pound of butter, and 1.3 gallons, or over 11 pounds of milk, for a pound of cheese. The corresponding estimates of the Dairy Division are 24 pounds milk per 1 pound butter and 10 pounds milk per 1 pound cheese. The two offices nearly agree in the equivalents of milk and cream, the one reckoning 5.5 gallons of milk as 1 gallon of cream and the other 5.5 pounds of milk as 1 pound of cream.

rearing of calves. In June, 1900, there were reported living nearly 53 calves under 1 year old for every 100 cows of all kinds over 2 years old. This was after a greater part of the veal calves of the year had been slaughtered. It is believed that 15,000,000 calves may be assumed to have been born and carried to an average age of at least six weeks from the 17,139,674 dairy cows on farms. This is, of course, an assumption, and must include calves fed for veal, mainly on whole milk, and calves raised for breeding and for beef, with more or less milk or none at all. It is now proposed to allow for these calves an average of 1 gallon of milk a day for about six weeks. This is purely an estimate, and will be by many regarded as excessive. It may be so, but it is more reasonable to thus dispose of the farm surplus of milk, which must be accounted for, than to count it as human food; and these are the only alternatives. Therefore the following table has been constructed to show the probable disposition of milk reported produced on farms, provided the census returns are correct. The total milk product, the sales of milk and cream, and the quantities of butter and cheese made on farms are from census tables.

TABLE II.—*Milk apparently available on farms and used or disposed of in 1899.*

Products and applications of milk.	Milk required.	
	Gallons.	Pounds.
Cheese made (16,372,330 pounds) <i>a</i>	19,037,593	163,723,300
Butter made (1,071,745,127 pounds) <i>b</i>	2,990,916,633	25,721,883,048
Cream sold (20,768,662 gallons) <i>c</i>	114,227,641	982,357,713
Milk sold (2,134,915,342 gallons) <i>d</i>	2,134,915,342	18,380,271,941
Total milk used or sold as above	5,259,097,209	45,228,236,002
Total milk reported produced on farms	7,266,392,674	62,490,976,996
Difference remaining available on farms	2,007,295,465	17,262,740,994
Estimate consumed by 15,000,000 calves	604,651,163	5,200,000,000
Remainder milk available for human food	1,402,644,302	12,062,740,994

a 1 pound cheese = 10 pounds of milk.*b* 1 pound butter = 24 pounds of milk.*c* 1 gallon cream = 47.3 pounds or 5.5 gallons milk.*d* 1 gallon milk = 8.6 pounds.

Assuming that there are 6 persons to 1 farm—4,514,210 farms to provide for = 27,085,260 persons. (12,062,740,994 pounds milk ÷ 27,085,260 persons = 445.36 pounds milk per capita per annum; 445.36 pounds milk per annum gives 1.22 pounds of milk per capita per diem on these farms.)

Notwithstanding the arbitrary assignment of about 8 per cent of the total farm milk product as used by calves, there remains a supply of milk equal to 310.7 gallons, or 2,672 pounds per annum per farm reporting, for use by persons living on the same farms. Allowing 6 persons per farm, the annual supply becomes 445.36 pounds of milk per capita, or 1.22 pounds per day. If this were true, the people on farms would consume new or whole milk at a rate double that which

would be available for those not living on farms, besides the farm supplies of skim milk and buttermilk. The improbability of any such rate of farm consumption again forces the conclusion that the farm sales of milk and cream were greater than reported and the total milk produced on farms was much less.

In further illustration of the relations of the production of milk on farms to its disposition another table is presented, containing extracts from the census returns, except that cream is expressed in equivalent gallons of milk, the States being arranged in the order of greatest milk production.

TABLE III—*Production of milk on farms and its disposition, in part, in the United States and in selected States for 1899. (From the census.)*

State.	Total milk produced on farms.	Total milk (and cream) sold from farms.	Milk (and cream) purchased by factories. ^a
	Gallons.	Gallons.	Gallons.
United States.....	7,266,392,674	2,249,142,983	1,510,502,090
New York.....	772,799,352	448,782,151	278,392,236
Iowa.....	585,872,240	232,615,344	217,193,098
Pennsylvania.....	487,088,818	174,001,607	111,577,740
Wisconsin.....	472,274,264	261,462,356	250,384,660
Illinois.....	457,106,995	189,632,261	125,014,634
Ohio.....	425,870,394	86,908,989	47,942,648
Massachusetts.....	105,571,873	80,917,357	18,734,648
New Jersey.....	77,714,055	50,923,939	5,981,150

^a See Census, 1900, Vol. V, p. CLXXIX.

Notwithstanding the doubts expressed as to the statistics given above, they are regarded as having sufficient approximate and comparative accuracy to furnish certain marked and interesting features.

It is impossible to tell to what extent farm returns failed to include in the sales the milk and cream delivered to cooperative creameries and cheese factories, the butter and cheese from which were included in manufactures and not in farm products or sales. There is evidence that such errors of omission occurred. The milk and cream received at factories must have been greater than returned, because the manufactured products of those establishments required materials considerably more than the quantities reported. The business of most of these factories is a matter of record, and yet an examination of the original returns made by them for the census shows that records of products are more definite and reliable, in many cases, than those of the milk and cream received as materials for manufacture.

States like Iowa and Wisconsin, having the creamery and factory system well developed and no large demands for city milk supply, both report the milk received at the factories as within 20,000,000

gallons of the milk sales reported by farms. It appears that in Wisconsin the farm sales constituted more than half of the total milk produced. Explanatory of this is the fact that the farm products of butter and cheese in this State were comparatively small. More than half of all the milk went to the factories; no other such case is shown in the table. Ohio, on the contrary, with exceptionally large quantities of butter and cheese made on the farms (and comparatively few creameries), sent only 11 per cent of the milk to be manufactured elsewhere, and shows sales, outside the factories, twice as large as Iowa or Wisconsin. Illinois, New York, and Pennsylvania well show the local demands for city milk supply; a large share of the milk produced was sold from the farms, and yet, although creameries and cheese factories are numerous in these States, such establishments did not receive more than two-thirds of the milk reported as sold. The statistics of Massachusetts and New Jersey have been included as examples of the effects of dense population and local markets for milk; a very large part of the milk produced is sold from the farms, but very small portions of this go to creameries and cheese factories.

It is deemed unfortunate that the gallon was selected as the unit of milk measure for the farm returns of the census. Although it may be a familiar farm measure, records of milk are rarely if ever kept in gallons. Commercial transactions in milk, including the business between creameries and cheese factories and the farmers ("patrons") who supply them, are now generally conducted in pounds, although sometimes expressed in quarts. The gallon is itself an uncertain quantity, the milk gallon differing considerably in different States, but the pound avoirdupois is the same the country over. In the computations and conversions made for this discussion and its tables, a gallon of milk has been regarded as 8.6 pounds and a gallon of cream as 8.2 pounds.

BUTTER ON FARMS.

Whereas the census has heretofore reported, in connection with butter on farms, the single fact of quantity made, the Twelfth Census adds three important and interesting items—the number of farms reporting butter as a home product, the quantity sold from farms, and the value of such sales. It thus appears that 3,617,440 farms, or 63 per cent of the total number, reported butter, the total quantity made in the year 1899 being 1,071,745,127 pounds. Of the latter, 518,139,026 pounds, or rather more than one-half, was sold for \$86,606,446, or at an average rate of 16.7 cents per pound.

The following table is taken from the agricultural volume (Part I) of the census for 1900:

TABLE IV.—*Butter made on farms and sales of same.* (Census of 1900.)

Geographic divisions.	Farms reporting butter.	Pounds made.	Pounds sold.	Received from sales.	Average price obtained per pound (cents).
The United States.....	3, 617, 440	1, 071, 745, 127	518, 139, 026	\$86, 606, 446	16. 7
North Atlantic.....	427, 220	206, 284, 451	145, 773, 945	28, 346, 852	19. 4
South Atlantic.....	507, 857	89, 111, 226	24, 432, 566	4, 214, 943	17. 3
North Central.....	1, 599, 111	539, 104, 750	284, 995, 556	42, 696, 824	15. 0
South Central.....	960, 678	185, 923, 880	32, 246, 106	5, 231, 213	16. 2
Western.....	122, 500	51, 202, 299	30, 694, 694	6, 062, 141	19. 9
Alaska.....	3	200	50	18	36. 0
Hawaii.....	71	118, 871	96, 209	35, 455	36. 9

Over one-half, or 50.3 per cent, of the butter reported from farms was made in the North Central Division and 19.2 per cent in the North Atlantic. The former division sold 55 per cent of its farm butter and the latter division 28.2 per cent. This shows where the surplus farm, or "dairy," butter is made. The South Central Division sold only 6.2 per cent of its farm product; the South Atlantic Division only 4.7 per cent, and the Western Division only 5.9 per cent.

It may be supposed that the returns of butter made on farms were as accurate as reported for the censuses of previous years as for that of 1900. Comparisons are therefore in order. The total product on farms reported every ten years from 1859 to 1899, inclusive, is given in Table X, on page 49. The farm-butter product per capita of population has been as follows: Census of 1850, 13.51 pounds; census of 1860, 14.62 pounds; census of 1870, 13.33 pounds; census of 1880, 15.50 pounds; census of 1890, 16.33 pounds, and census of 1900, 14.06 pounds of farm butter per capita per annum. Since 1880, and including that year, creamery butter also has been produced in rapidly increasing quantity. Therefore the per capita production of farm butter has been quite variable, and, although the rate increased during the decade prior to 1890, notwithstanding a very large increase of creamery butter during the same period, the last decade shows a decrease in rate exceeding anything previous; while, at the same time, the total production of butter on farms, as reported by the Twelfth Census, was somewhat greater than ever before.

The five States producing the greatest quantity of butter on farms were, in the order named, Ohio, New York, Pennsylvania, Iowa, and Michigan. Together they produced almost one-third of the total.

In the discussion of the statistics of dairy products in the agricultural volume of the Twelfth Census, it is stated that, for reasons

already referred to, the butter reported as made on farms should probably be reduced by 7,400,000 pounds and the milk sales correspondingly increased. This correction is considered as belonging to the returns for the States of Vermont, Minnesota, Kansas, and Nebraska. Besides this, the census estimates that butter was made on farms and not reported to the amount of 50,000,000 pounds.

CHEESE ON FARMS.

The quantity of cheese made on farms has decreased steadily ever since the beginning of the factory system of manufacture in this country—about fifty years ago. The number of farms reporting cheese in 1900 was only 15,670, or one farm in every 366. Of these farms, approximately half were in the North Central Division and one-half of the remainder in the North Atlantic States. But the Western Division reported more cheese made on farms than any other geographical division, because the State of California was credited with 4,249,588 pounds, or over one-fourth of the total product on farms, which was 16,372,330 pounds. New York was next, with 2,624,552 pounds, and the States of Wisconsin and Ohio were the only others in which over 1,000,000 pounds were made during the census year, although Pennsylvania approached that quantity. But every State and Territory in the Union reported some cheese made on farms. Massachusetts, Rhode Island, Delaware, South Carolina, Georgia, Florida, Arkansas, and Indian Territory were the only ones reporting less than 20,000 pounds each. Cheese making on farms is therefore a widely diffused industry still, despite the preponderance of factory-made cheese.

More than seven-eighths of this home-made cheese was sold from the farms. The average price reported received for it was 9.1 cents per pound. In the North Atlantic and Western Divisions the averages were the same, 9.6 cents; this was the rate in New York, while in California it was but 9.1 cents. In Wisconsin the average was but 8.7 cents, and in Ohio 6.8 cents.

As compared with the Eleventh Census, the Twelfth shows a decrease in the whole country of nearly 2,500,000 pounds of farm-made cheese per year, or 12.6 per cent, although the total cheese product of the United States appears to have increased over 16 per cent.^a

^a See modifying statement on p. 42.

FARM SALES OF DAIRY PRODUCTS.

Following is a general summary of the quantities and values of dairy products sold from 4,514,210 farms in the United States, and the totals of such products thereon, as reported by the census for 1900:

Milk sold, 2,134,915,342 gallons.....	\$184, 842, 292
Cream sold, 20,768,662 gallons.....	8, 838, 776
Butter sold, 518,139,026 pounds	86, 606, 446
Cheese sold, 14,692,542 pounds.....	1, 342, 444
Total value of dairy products sold from farms	281, 629, 958
Total value of such products consumed on farms....	190, 739, 297
Aggregate value of dairy products on farms, 1899 ..	472, 369, 255

The totals given include the small returns from Alaska and Hawaii. The average value of dairy products per farm reporting was \$104.64, and the average annual sales of such products per farm was only \$62.39. The census of 1900, in the discussion of these data, expresses the opinion that, by reason of errors and omissions, the totals above are considerably below the actual facts.

BUTTER, CHEESE, AND CONDENSED-MILK FACTORIES.

One of the most striking features in the history of dairy farming in the United States is the transfer of this productive industry, in large part, from the farm to the factory. The cows and milk continue to be farm property and products, but a constantly increasing share of the labor of converting milk into market form is done at creameries, cheese factories, and condenseries. This change has transpired during the last half century, which covers the period of development of associated and cooperative dairying in America. When the milk produced on two or more farms or the cream from such milk is brought together at one place to be condensed or made into cheese or butter, domestic industry ceases, the place becomes a factory, and its output a manufactured product.

Consequently, for census purposes, the statistics of the dairy industry in the United States are collected and compiled in two distinct parts, by different sets of employees, under separate supervision, and published in separate volumes. The products and sales of farms appear in the agricultural tables as one part and the materials and products of the dairy factories appear in the tables of manufactures as another part. The reasons for this are sound from the standpoint of the Director of the Census, but the result is unsatisfactory to those who wish to study and use the data. One serious objection to this plan is the entire separation of the statistics of raw materials produced and disposed of by farms from those of the dairy establishments preparing the market products. The two parts can only be adjusted and harmonized by violent methods.

The Seventh Census noted the existence of 8 cheese factories in 1850. The number increased very little until after 1860. In 1870, there were reported 1,313 cheese factories and butter factories, generally called creameries. The census for 1880 reported 3,932, and that for 1890 gave the number at 4,712. The latter was the number of establishments from which reports were rendered; it is well known, however, that a considerable number of such factories, probably 2,500, were then actually in operation from which no returns were obtained for the Eleventh Census. This fact should be borne in mind. Although the figures for different years are brought together in tables which follow, as a matter of record, direct comparisons will, in most cases, be very misleading.

The returns for 1900 include the statistics of 9,242 butter, cheese, and condensed-milk factories. These central plants have under their control 2,050 skimming, or separating, stations and 747 other branches. There are also 113 urban establishments reporting the manufacture of butter or cheese or both. These latter are, in a few cases, creameries located in cities and which escaped the regular enumerators, but in most instances they are milk-supply establishments which simply manufacture their variable surplus of milk and cream. Their products, amounting to several hundred thousand pounds of butter and cheese annually, can not be ignored, and these data are distributed to their respective States in some of the tables following. The total number of establishments in the country for 1900 is therefore 9,355, and the principal data concerning them will be found in the table below, which shows the distribution of the dairy factories of 1900, by States and Territories, and their classification according to products.

TABLE V.—*Cheese, butter, and condensed-milk factories: Number of establishments in each class, classified according to products, by States and Territories, 1900.*

States and Territories.	Total number of establishments.	Butter only produced.	Cheese only produced.	Condensed milk only produced.	Cream for sale the only product.	Two or more products reported.
United States.....	9,242	5,275	3,299	38	47	563
Alabama.....	4	3	1	.....	.....	.....
Arizona.....	7	1	1	.....	.....	5
Arkansas.....	8	7	.....	.....	.....	1
California.....	178	143	17	2	1	15
Colorado.....	38	20	9	.....	1	8
Connecticut.....	71	62	2	.....	.....	7
Delaware.....	22	21	1	.....	.....	.....
Georgia.....	4	4	.....	.....	.....	.....
Idaho.....	19	11	4	.....	.....	4
Illinois.....	527	393	51	6	5	72
Indiana.....	112	75	26	.....	.....	11
Iowa.....	907	816	81	.....	2	8

TABLE V.—*Cheese, butter, and condensed-milk factories, etc.*—Continued.

States and Territories.	Total number of establishments.	Butter only produced.	Cheese only produced.	Con-densed milk only produced.	Cream for sale the only product.	Two or more products reported.
Kansas	171	138	30	1	.....	7
Kentucky	9	7	1	.....	.....	1
Maine	61	44	16	1	.....	.....
Maryland	84	78	.....	.....	6	.....
Massachusetts	50	46	1	.....	1	2
Michigan	286	146	180	3	1	6
Minnesota	596	588	47	.....	3	8
Mississippi	2	2	.....	.....	.....	.....
Missouri	79	48	24	1	.....	6
Montana	3	3	.....	.....	.....	.....
Nebraska	98	82	5	.....	1	5
Nevada	4	2	.....	.....	.....	2
New Hampshire	53	47	4	1	1	.....
New Jersey	58	47	1	1	4	.....
New York	1,908	575	1,151	12	4	166
North Dakota	21	13	8	.....	.....	.....
Ohio	479	147	221	1	11	99
Oklahoma	5	2	3	.....	.....	.....
Oregon	68	39	16	.....	1	12
Pennsylvania	749	603	124	3	3	16
Rhode Island	3	3	.....	.....	.....	.....
South Dakota	138	122	14	.....	.....	2
Tennessee	12	11	1	.....	.....	.....
Texas	12	9	2	.....	.....	1
Utah	57	21	7	.....	.....	29
Vermont	255	180	61	2	2	10
Virginia	10	8	2	.....	.....	.....
Washington	60	33	8	1	.....	18
West Virginia	4	1	2	.....	.....	1
Wisconsin	2,018	728	1,227	3	.....	60
Wyoming	2	1	.....	.....	.....	1

THE ASSOCIATED SYSTEM OF DAIRYING.

The statement has been frequently made that the associated system of dairying originated in this country, and it has been called "The American system." Those who first associated themselves and brought milk together from different farms for making butter and cheese probably never heard of such methods elsewhere, and so were originators for their own time and neighborhoods. But the change was only a natural evolution in the industry here, and the same thing had been done long before in other lands. In the Jura Mountain region of France and Switzerland, cooperative cheese making has been systematically practiced for at least four centuries and probably much longer. In the United States, cooperation among dairymen was first applied in making cheese. This plan attracted attention and was recognized as successful in Oneida County, N. Y., about 1852. Very slowly the

cheese factory became an established institution. Once fairly started in the heart of the cheese-making district of New York, the factory system spread with much rapidity. The "war period," during which the price of cheese more than doubled, lent additional impetus to the movement. A like effect was produced from the increase in cheese exports which occurred about the same time. These exports rose from 13,020,817 pounds in 1850 to 15,515,799 in 1860, and to 53,154,318 in 1865; ten years later 101,010,853 pounds of cheese were exported. The early growth of this factory system is shown in the following table:

TABLE VI.—*Number of cheese factories established in the State of New York annually, 1854-1866.*

Years.	Facto- ries.	Years.	Facto- ries.	Years.	Facto- ries.
1854.....	4	1860.....	17	1866.....	46
1855.....	2	1861.....	18	Total number in operation in 1866.	499
1856.....	3	1862.....	25		
1857.....	3	1863.....	111		
1858.....	4	1864.....	210		
1859.....	4	1865.....	52		

Cheese factories were started in Pennsylvania and Ohio soon after they became popular in New York, and then they appeared in other States both East and West.

Making butter in quantity from milk or cream collected from numerous farms soon followed the introduction of cheese factories. Such establishments are properly butter factories, but the name "creamery" has been generally adopted and is not likely to be changed. So far as known, the creamery system of butter making originated in the United States. The first creamery was built in Orange County, N. Y., in the year 1864, and received daily the milk from 375 cows. In Illinois the first cheese factory was started in 1863 and the first creamery in 1867. In Iowa these respective events were in 1866 and 1871.

The early cheese factories and creameries were purely cooperative concerns, and it is in this form that the system has usually extended into new territory, whether for the production of butter or cheese. There are, however, various other forms of ownership and management, involving the cooperative principle in part or being purely proprietary.

It was impossible to separate these establishments in classes according to all the modifications of ownership and management for the Twelfth Census, but four groups were made: Individual, 4,507; firm, 1,335; corporation, 1,591; cooperative, 1,813; total, 9,246. It thus appears that the proprietary plan or private ownership is now greatly

in excess of the cooperative system. The tendency has been toward changes in this direction for a number of years. In New England less than twenty years ago all the creameries were cooperative; now a bare majority so remain in Maine, New Hampshire, and Massachusetts. In Iowa, where the cooperative plan formerly prevailed, less than one-third still remain of that form. Minnesota creameries were for years almost all cooperative; about 60 per cent continue to be so. As examples of the other extreme, only 8 factories are cooperative out of 178 in California, only 13 out of 171 in Kansas, and only 372 out of 2,018 in Wisconsin.

Although establishments of this kind are usually successful, there is misjudgment and failure as in other lines of industry. Many have been started by "promoters," injudiciously located, or overcapitalized, and closed after brief careers. Fires, consolidations, and other changes of ownership add to the causes for frequent changes. Of the 9,246 establishments enumerated in 1900, 5,463, or over one-half, were reported as established within the preceding decade, and 439 as started during the census year.

During the earlier years of their operation it was not uncommon for both butter and cheese to be made in these factories at different seasons, or butter and skim cheese at the same time. A more distinct separation has resulted from a healthy sentiment (aided by State laws) to make full-cream cheese, and from a preference on the part of creameries to have no cheese making about the premises. The totals from Table V, on page 28, according to their products, are as follows:

Number making butter only	5,275
Number making cheese only	3,299
Number making condensed milk only	38
Number selling cream	47
Number reporting two or more products	583

Of the last group, there are 571 which make both butter and cheese, 11 which make butter and condensed milk, and 1 which makes cheese and condensed milk. In order to make desirable averages and comparisons, and at the same time avoid duplications, a rearrangement is necessary, by which the combined establishments are arbitrarily but equitably distributed. This being done, the following classification is obtained for the whole country:

Creameries	5,567
Condenseries	43
Cheese factories	3,585
Cream shippers	47
Total	9,242

No factory is counted twice in this arrangement. Recognizing the dual character of some establishments, it is found that there are altogether 5,857 where butter is made and 3,872 where cheese is made.

Under this classification without duplication, Iowa has the greatest number of creameries, 820, and Wisconsin next, 759; then New York 659, Pennsylvania 611, Minnesota 542, and Illinois 430. No other State has as many as 200. As to cheese factories, the States having the greatest number are: Wisconsin 1,256, New York, 1,231, Ohio 271, Michigan 132, and Pennsylvania 132. No other State has more than 90.

By the census of 1890, the three States which reported the greatest number of creameries and cheese factories together were New York 1,337, Wisconsin 966, and Iowa 500. The same States stand at the head in 1900, but Wisconsin and New York change places; these two States divide their establishments similarly, there being in each somewhat more than half as many creameries as cheese factories. Iowa, holding third place, is preeminently a butter-making State, with more creameries than any other, but only 85 cheese factories. During the last twenty years creameries have increased in number much faster than cheese factories, and the system has extended into new territory, especially in the North Central and Western States. A comparatively new plan is the organization of large companies which establish a central manufacturing plant, and transport to this the raw material in the form of cream or milk, usually the former. This is collected from branches known as shipping stations and skimming stations, at which deliveries are made by the farmers of the neighborhood. Cream is thus gathered and carried long distances by rail to the main creamery.

The extent of associated dairying in some States, especially Kansas and Nebraska, would not be understood from Table V without explanations. Although reporting only 171 and 93 factories, respectively, of all kinds, in 1900, there were in addition 307 and 284 shipping stations, or separating and skimming stations, in these two States. Many of these were formerly independent creameries or cheese factories which have been absorbed by the large companies, and thus ceased to be manufacturing plants. The returns show that in 1900 there were 473 centrifugal cream separators in operation in these creameries and their branches in Kansas, and 324 separators in Nebraska factories and branches. Vermont is another example of a largely increased factory production, apparently out of proportion to the number of new establishments. Consolidation and large companies with branches explain the facts there also. Vermont reported 184 skimming stations in operation in 1900, and 382 power separators in use by the creameries of that State and their stations or branches.

AVERAGE PRODUCT OF FACTORIES.

There is much difference in the size of the factories in the several States. In New York and Pennsylvania the creameries are small, the average annual product being, respectively, 57,000 and 59,000 pounds of butter. In Illinois and Minnesota the average is 72,000 and 75,000

pounds, respectively, and in Wisconsin 91,000 pounds. In Iowa they are larger, with an annual output of 104,000 pounds. Vermont and Kansas show the influence of a few large establishments by raising the average to 121,000 and 133,000 pounds, respectively. Some of the large creameries make from 2,000,000 to 4,000,000 pounds of butter a year. For the entire country the average product of a creamery for a year is 71,730 pounds of butter. Similar differences exist among the cheese factories; the largest are in New York, where the average product is 97,000 pounds a year, and in Wisconsin, where there are many small factories, the average is brought down to 61,000 pounds. In Michigan and Pennsylvania the average is 75,000 or 76,000 pounds. The annual product of the average cheese factory for the whole country is a little larger than for the average creamery, or nearly 73,000 pounds. A few report the production of 500,000 to 1,500,000 pounds a year. (The round numbers given are approximately correct, due allowance being made for some factories which can not properly be included.) It must be remembered, however, that this represents only 730,000 pounds of milk used by the average cheese factory in a year, while the average creamery requires over 1,500,000 pounds of milk for its annual product of butter. This does not indicate that twice as many cows are necessary to support a creamery as for a cheese factory, because, as a rule, the latter is in operation only during the pasturage season, or about half the year, while in most cases the creamery makes butter the entire year. In fact, the average creamery represents, while in operation, the milk from 450 cows, and the average cheese factory 300 or more cows. In the aggregate, the creameries of the United States appear to use all the milk from about 2,600,000 cows throughout the year, or an average of 160 pounds of butter per cow, and the cheese factories use the milk from 1,130,000 cows for half the year, representing an average product of 250 pounds of cheese in six months.

CREAMERIES AND THEIR PRODUCTS.

The creamery system was introduced east of the Hudson River but little more than twenty years ago, upon what was known as the "cream-gathering" plan. This was a popular form of creamery management in some Western States and in parts of the Middle States from 1876 or 1878 until after 1890. Under this plan the cream was separated by gravity (or "setting") on the producing farms, skimmed there, and the cream only went to the creamery, being usually collected daily by agents, or gatherers, from the factory, whence the name. The dairy centrifuge, or cream separator, made its appearance in America in the year 1879, and has revolutionized dairy and creamery management. The popularity of this machine for mechanical skimming or separation of cream dates from about 1885, and since

that time "the separator plan" has been adopted by practically all new factories and has rapidly replaced the cream-gathering plan in established creameries. The separator, operated by power, has been placed at the creamery and at its branches or separating stations; the milk for butter has been hauled daily to these places to be there creamed or separated. This radical change of management accounts for the decrease in cream as a "material" received by the creameries, and partly for the increased quantity of milk so received.

That cream-gathering creameries have not ceased to exist is evident from the quantity of cream still included in the creamery receipts of "material." There were 203,673,958 pounds reported for 1900; of this, 63,308,657 pounds (7,720,568 gallons) were sold by the creameries, leaving 140,365,301 pounds, or enough to make 40,000,000 pounds of butter, being almost 10 per cent of the entire creamery output. Iowa is a good example, although not a strong cream-gathering State. It is known that 10 per cent of all creameries in Iowa are conducted on the gathered-cream plan, and 7 per cent in addition combine this plan with that of receiving whole milk to be separated at the creamery.

CREAMERY MATERIALS AND EQUIPMENT.

The large quantity of cream still appearing as raw material at the creameries is indicative of another change in system and suggestive of another great dairy invention. The centrifugal cream separator was introduced and generally adopted in large sizes, requiring steam power, and of such capacity that one machine, operated a few hours every morning, could cream the milk from several hundred cows. One powerful separator is therefore the usual equipment of a creamery and does the work for a whole neighborhood. It has been found that the labor and expenses of daily hauling the entire milk product of patrons' farms to the creamery, often several miles distant, is too great a tax upon the industry. A movement toward relief to the patrons, and economy to creamery management, has been the establishment of neighborhood "skimming stations," equipped only with separator and power to operate it, as branches of the central plant. From these stations the cream is transported to the parent butter-making factory. These centrifugal separators in use by creameries were first enumerated for the present census; also, for the first time, the branch factories or separating, or skimming stations. There were returned 9,701 separators, and 2,719 branch stations of all kinds. While cheese factories sometimes have branches of the parent establishment, they do not have separating, or skimming stations; all the latter class of subsidiary establishments may therefore be taken as belonging to creameries, and a part of the other branch factories. Hence, if to the 5,571 creameries there be added 2,050 skimming stations and 69 other

branches, 7,690 establishments are found having use for separators. Over 2,000 creameries, therefore, use two or more separators. The exact number still operated without the centrifuge, or upon the old cream-gathering plan, remains undetermined.

The new elements influencing modification in the creamery system are the invention of what is known as the Babcock fat test for milk and the adoption of the farm separator in sizes for either hand or power. Milk delivered at creameries and cheese factories is now generally tested and paid for on the basis of its fat content or butter-making value. Farm and creamery methods are so much simplified by these improvements that many dairy farmers are procuring private separators. The State dairy commissioner of Iowa reports 904 farm separators owned by patrons of creameries in 1898, 1,762 in 1899, 3,332 in 1900, 5,231 in 1901, 8,323 in 1902, and 16,800 in 1903. This new form of the "cream-gathering plan" is rapidly extending; cream again forms a large share of the raw material received at the factories for butter making, and the next census will probably show, instead of a decrease, a very considerable increase in this item.

CREAMERY PRODUCTS.

The quantity of butter made at creameries has been reported under two heads—"packed solid" and "prints or rolls." It appears that of all creamery butter, 328,956,590 pounds, or 78.3 per cent, is packed in solid form, and 91,169,956 pounds, or 21.7 per cent, as prints or rolls. The totals of these two forms in the several States indicate differences in the market requirements and the local customs as to preparing butter for shipment and sale. In the New England States, the numerous cities and large towns, easy of access, furnish markets where butter can be sold directly to retail dealers and largely to consumers; for this purpose it is prepared in lumps, bricks, or prints, weighing a half pound or a pound. Vermont excepted, the creameries of these States make twice as much butter into prints as they pack in solid form. In Rhode Island and Connecticut, with consuming markets at their doors, 8 pounds of creamery butter are put into prints to every pound packed. In Vermont, on the contrary, with little local demand and the necessity of shipping to market, about one-fourth of the creamery butter is made into prints. New York has always been in the habit of packing butter solidly in firkins, tubs, or boxes, and print butter is rather exceptional in the great market of New York City; in this State, therefore, $4\frac{1}{2}$ pounds of butter are packed to 1 pound put in prints. The Philadelphia market, on the contrary, and Pennsylvania markets in general, have always been noted for print butter; consequently it is not surprising to find that the creameries of this State report almost twice as much made into prints as the quantity solid packed. From Iowa, Wisconsin, and

Minnesota, butter must be sent long distances to market, and naturally goes mainly in bulk; less than one-eighteenth of the creamery product in these States is made into prints. South Dakota, even more remote from market, packs 90 per cent of its creamery butter in solid form. But upon the Pacific coast, local custom favors butter in rolls of 2 pounds weight; accordingly, in the States of California, Oregon, and Washington three-fourths of all the butter made at creameries is reported to be in prints or rolls.

BUTTER PRICES.

Creameries which are able to market butter in the form of prints or rolls generally derive a benefit therefrom. Although extra labor is required to prepare butter in this way, and packages and transportation for it cost rather more, it is a retail form, attractive, brings a higher price, and can be sold more directly to the consumer, saving the commissions of the middlemen. The average price obtained for all butter, as reported by the creameries for the census year, was very nearly 20.1 cents per pound. The average for that solid packed, for the whole country, was 19.4 cents, and for the prints or rolls 22.1 cents. The advantage of nearby markets is shown by these average prices for print butter: Connecticut, 24.6 cents per pound; Massachusetts, 23.5 cents; and Pennsylvania, 23.4 cents. For California creamery rolls the average is 22.3 cents. Contrasted with these is the average price for the packed, or tub, butter of Iowa, Minnesota, and Wisconsin creameries, 19 cents; 18 cents for Nebraska, and 17 for Kansas.

RICHNESS OF MILK, OR BUTTER RATIO.

Assuming the substantial accuracy of the returns from creameries of milk and cream received for making butter, and of the butter made from it, interesting computations can be made of the ratio of milk to butter in the country at large and the several States. The results illustrate the difference in the average richness of milk in different States. The nearest quarter-pound obtained in each calculation is taken as quite accurate enough for purposes of comparison. It is thus found that creameries of the United States require on the average $22\frac{1}{4}$ pounds of milk, or its equivalent in cream, to make 1 pound of merchantable butter. New York appears to have the richest milk of any of the leading dairy States, its creameries making 1 pound of butter from every 21 pounds of milk received. New Hampshire stands second, with a ratio of $21\frac{1}{4}$ to 1; and California third, $21\frac{1}{4}$ to 1. Minnesota, Pennsylvania, and Wisconsin are alike, showing 22 pounds as the average; then Illinois $22\frac{1}{4}$, Kansas and Vermont $23\frac{1}{4}$, and Iowa 24 pounds. These ten States suffice for illustration. The results can not be accepted as absolutely accurate; it is probable that the average

pounds of milk stated for the country at large, and for most of the States named, is somewhat below the truth. For the United States the ratio stated would indicate all milk contributed to creameries to have an average of 3.81 per cent of butter fat. For New York the average would have to be 4.08 per cent fat. It is not likely that the average richness of milk is so great as this. Nor is it probable that there is so great a difference between New Hampshire (and New York) and Vermont in this respect. The comparison between Minnesota and Wisconsin, Illinois and Iowa, is believed to be correct; Wisconsin has large holdings of "special purpose cows" which give rich milk, and the same is true of Minnesota to a considerable degree; while in Iowa the "general purpose cow" is popular, giving less milk and poorer in butter quality.

If, instead of the above, 2½ pounds of milk is assumed as the required average for the whole country to make a pound of creamery butter, this would necessitate milk with an average of 3.7267 per cent of butter fat. No State has dared to fix a legal standard so high as this for milk produced within its borders, and only one has a standard above 3.5 per cent.

CREAM SALES.

The returns of creamery products give evidence that the sale of cream has become a large and profitable branch of the business in some States. The creameries of New York, Illinois, Ohio, and Pennsylvania made sales of cream, respectively, as follows: 1,492,926 gallons at 53 cents, 1,190,125 gallons at 56 cents, 787,331 gallons at 50 cents, and 686,316 gallons at 58 cents. A different and notable case is that of the State of Maine; its creameries sold 755,845 gallons of cream at 71 cents a gallon, or \$534,295, and this was considered more than half as much as the total butter sales of the State. No other State sold as much as 500,000 gallons. The quantity of cream reported as sold by all the creameries of the country was 7,720,569 gallons, valued at \$4,435,444, or 57 cents per gallon; the profit of this branch of the business is seen by the fact that, at the average creamery receipts for butter, this quantity of cream, if made into butter, would have realized only \$3,438,754. Ordinarily the gallon of cream thus sold would be the equivalent of a fraction less than 2 pounds of butter.

SKIM MILK.

Of this by-product of the creameries the great amount of 2,253,494,156 pounds is reported as "sold, fed, or returned to patrons." The total value is given at \$2,531,460, or 11.23 cents per 100 pounds. Skim milk is actually worth twice as much as this to farmers who use it judiciously as food for young stock. But commercially it is worth less, or about 10 cents per 100 pounds; this is the usual price allowed to patrons who sell it to the creameries for conversion into casein.

DRIED CASEIN.

A comparatively new branch of the dairy industry, which has acquired importance enough to be observed, is the production of commercial casein from the skim milk of creameries. Milk from which all the fat has been extracted by the separator is coagulated by acid, the whey drawn off, the acid washed from the curd, or casein, then dried. The desiccated product has a commercial value of 3 to 5 cents per pound at the creameries where made, depending largely upon subsequent cost of transportation, and is used for making a glue good for paper sizing, as a binder for cheap paint, a "filler" for dressing wood and heavy fabrics, and for various other purposes. The statistics of creamery products show 12,298,405 pounds of this material made during the census year, having a value, at the creameries, of \$383,581, or only a little more than 3 cents a pound. The State of New York produced more than half the total quantity, and Pennsylvania and Illinois are the only others in which over 1,000,000 pounds were made.

CHEESE FACTORIES AND THEIR PRODUCTS.

The management of the cheese factory is in some respects similar to that of the creamery. Patrons deliver at the factory daily the whole milk while still sweet and sound, and it is made into cheese without delay. Cheese is usually the only commercial product of the factory, and the only waste product is whey. The latter may be returned to patrons, or fed to hogs at the factory, or sold to be used as the material for making sugar of milk. For a score of years or more after these factories became numerous, the cheese from them, although different in form, size, color, and quality, was nearly all made upon the same general plan, closely resembling that of the English Cheddar. Hence a certain uniformity of type was established which became known as the "standard American" or "full-cream factory" cheese, also often called Cheddar. During the last ten or twenty years, however, a much greater variety has entered into the factory cheese; this is chiefly the result of imitating certain popular foreign kinds. The recent census has, for the first time, attempted to classify the factory product. It appears that the 3,585 cheese factories of the United States report a total production of 281,972,324 pounds of cheese during the census year (as against 238,035,065 pounds reported in 1890), and that 225,776,105 pounds was of the American standard factory kind, and 56,196,219 pounds, or 20 per cent, of the several other varieties.

The great cheese factory States are the same as at the time of the Eleventh Census, as has been already noted. In New York, 89.2 per cent of the product is of the standard, full-cream, Cheddar-made variety, and this kind preponderates in Ohio, Michigan, and Pennsylvania; these are the oldest cheese-making States. In Wisconsin the 77,748,680 pounds is divided as follows: American standard, 62.1 per

cent, and the other kinds, 37.9 per cent. In Illinois, however, the standard is exceeded in quantity by the others—4,324,461 pounds of the former to 4,730,658 pounds of the latter. These “other kinds” comprise various well-known foreign varieties, those made in large quantity being mainly the Swiss Gruyère, or Emmenthaler, and the Limburger; there are also some resembling one or both of these, especially the “Brick” cheese. The Neufchâtel and cream cheese, the Brie and Camembert, are also made in considerable quantities. The value of cheese at the factory is reported as averaging nearly 9.5 cents a pound, being a little more for the standard variety than the average for all other kinds.

WHEY.

The quantity of whey reported as the waste product of cheese factories is 209,067,667 pounds, but this had a value of only \$204,277; it appears that of this only 21.3 per cent was sold and the rest “used” or returned to the patrons. As milk sugar is the sole commercial product for which whey is utilized in this country, it is probable that all reported sold was for that purpose. The quantity of sugar of milk manufactured was not ascertained; there are only three or four places in the United States where this article is made, and yet it is produced here in greater quantity than anywhere else in the world.

MILK CONDENSERIES AND THEIR PRODUCTS.

The condensed-milk industry was started about the same time as the factory system for making butter and cheese. Some method had long been sought for preserving milk, but none was successful until the invention of Gail Borden. After ten years of experimenting, he decided that a semiliquid state was the best form of preservation, and in 1856 settled upon the process which has since popularized the product in every quarter of the globe. The present extensive industry in Europe as well as in America, with its numerous different establishments and many commercial names, or brands, is based upon Mr. Borden's methods. This applies to the unsweetened article as well as that preserved with sugar, for “plain condensed milk” was first introduced and put upon the market about the year 1861. It was then mainly in open vessels and intended for early use. Between 1860 and 1870, milk in both forms had become well known, and four or five factories were in operation, each producing about five thousand 1-pound cans per day.

Prior to the Twelfth Census, the statistics of this industry were few: In 1880, the total annual product was reported as 13,033,267 pounds, valued at \$1,547,588, and ten years later the same items were 37,926,821 pounds, valued at \$3,586,927. For 1890, the total materials reported as used cost \$2,792,086, and included 83,617,655 pounds of

milk and 13,372,365 pounds of sugar. There is little doubt that these figures were considerably below the actual facts.

It now appears that in the year 1900 there were 50 establishments for condensing milk, operating in 14 different States, with a business shown by the following aggregates:

Milk bought (421, 378, 073 pounds)	\$4, 662, 437
Sugar bought (50, 873, 859 pounds).....	2, 589, 687
Cans, labels, etc.....	1, 654, 897
Materials used, aggregate cost	8, 907, 021
Condensed milk (186, 921, 787 pounds).....	11, 888, 792
Other and incidental products.....	33, 680
Products, aggregate value	11, 922, 472

The two States of New York and Illinois contain more than half of the condenseries reported, and produce over three-fourths of the entire output. Eleven States each produced over 1,000,000 pounds of condensed milk during the census year. Arranged in the order of greatest product, they were these (the figures following the names indicate the number of condenseries from which statistics were obtained; the number of these establishments, with the position of the State in this list, give a fair idea of the relative size and importance of the condenseries): New York (16), Illinois (11), Michigan (4), California (2), Wisconsin (4), Pennsylvania (3), New Hampshire (1), Maine (1), Vermont (2), Washington (1), and New Jersey (1). The total product in New York was 75,447,148 pounds, followed closely by Illinois, with 71,257,449. As the latter State has only 11 factories, while the former has 16, the size of those in Illinois must be relatively larger. Michigan made 18,378,869 pounds of condensed milk, but no other State in the above list made as much as 5,000,000 pounds. Missouri, Indiana, Kansas, and Ohio, with one condensery each, produced from 380,500 to 100,000 pounds.

Of the 50 establishments reported, 38 had condensed milk as their only product; 11 made butter also. The latter class is highly suggestive of a skimmed or partly skimmed article of milk being condensed. Five of these factories are in Illinois and 3 in New York. One factory in New York made both cheese and condensed milk, and one in Illinois made both of these articles and butter also.

There are several interesting items in the statistics of this industry. Although a considerable but unknown part of the product is the plain or unsweetened article, the sugar used for the remainder costs more than half as much as all of the milk condensed and preserved. The materials have a total value of \$8,907,021, and that of the finished product is \$11,922,472 for the whole country. But the cost of manufacture includes, besides the materials, the use and wear and tear of the factories, with their expensive machinery and general equipment,

and the wages of many skilled employees. The value of the condensed milk at the factories appears to average a little over 6½ cents per pound in cans. There is a variation between 6 and 7 cents in different States, which is easily accounted for. In some the proportion of unsweetened milk is much greater and the cost and value correspondingly less. The quality of milk and of condensed product is very much better in some cases than in others, and the consequent cost and value are more. Under the general designation of "condensed milk" are included all the preparations of milk from which a large part of the water has been evaporated, including sweetened and unsweetened "condensed milk," "evaporated milk," "condensed cream," and "evaporated cream." These names are rather indiscriminately used, as cream or even enriched milk is seldom condensed or evaporated, while it is unfortunately true, on the other hand, that much poor and skimmed milk is condensed without being so marked or named.

MILK PRICES.

The census returns of the prices to patrons for milk are probably not altogether reliable, although they can not be far from the truth. It appears that for the census year the average price paid to producers delivering milk to butter factories was 77 cents per 100 pounds, while cheese factories paid an average of 78 cents and condensed-milk factories \$1.11. According to the returns, the prices for milk for making butter ranged from 64 and 65 cents per 100 pounds in Kansas, South Dakota, Utah, and Wyoming, and 77 cents (the average) in Illinois and Iowa, to 82 cents in New York, 86 (average) in California, Oregon, and Washington, 90 in Pennsylvania, 93 in New Hampshire, 95 in Massachusetts, and \$1.08 in Connecticut. For cheese making, the factories paid an average of 86 cents per 100 pounds for milk in California, 83 cents in New York, 76 in Michigan, 74 in Wisconsin, and 72 in Ohio. Condenseries are reported as paying 96 cents per 100 pounds for milk in Illinois, \$1.14 in California, \$1.15 in Pennsylvania, and \$1.35 in New York.

AGGREGATE PRODUCTION OF BUTTER AND CHEESE.

The total of 1,071,745,127 pounds of butter made on farms and 420,954,016 pounds in creameries (including urban establishments) give an aggregate production of 1,492,699,143 pounds of butter in the United States for the last census year; and the census authorities estimate that in addition more than 50,000,000 pounds were actually made which escaped the returns.

It is interesting to note that, while the extension of the associated system has been such as to raise apparently the product of the creameries during the decade of 1890-1900 from 15.2 to 28.2 per cent of

the entire quantity of butter made in this country, the portion reported from farms has increased less than 50,000,000 pounds, and has relatively decreased from 81.8 per cent of the whole to 71.8 per cent.

This aggregate annual production of butter is at the rate of 502 pounds to every square mile of land area in the United States, exclusive of Alaska, and furnishes a supply of 19.57 pounds per capita of the population, being 14.06 pounds of farm dairy butter and 5.51 pounds of creamery butter. According to the Eleventh Census the per capita supply was 16.33 pounds from the farm and 2.91 pounds from the factory, or 19.24 pounds in all. In 1880 the supply was 15.50 and 0.58 pounds, or 16.08 per unit of population. In other census years the returns show, for 1870, a supply of 13.33 pounds per capita; for 1860, 14.62 pounds; and for 1850, 13.51 pounds.

As a rule the States producing the greatest quantities of butter in factories are also those in which the quantities made on farms are greatest. Ohio is a notable exception; it produced 79,551,299 pounds of butter on farms, which is more than any other State, while its creamery product was comparatively small, being only 8,117,321 pounds. By combining the products of farm and factory the five States which lead all the others in total butter produced appear as follows: Iowa stands first, with 139,022,552 pounds, and then follow New York, 115,606,980 pounds; Pennsylvania, 111,394,966 pounds; Wisconsin, 106,573,740 pounds; and Illinois, 86,600,162 pounds. In Iowa and Wisconsin creameries produced more than farms, but in Pennsylvania, New York, and Illinois the reverse was true. According to the Eleventh Census the five States showing the greatest production of butter were Iowa, New York, Pennsylvania, Illinois, and Ohio; Wisconsin held the sixth place.

Of cheese, the total production on farms, for the last census year, was 16,372,330 pounds, and in factories (of all kinds) it was 282,634,488 pounds, or an aggregate of 299,006,818 pounds. Compared with the reports of the Eleventh Census, the total made on the farm has decreased and the total factory product has increased. But although the increase for the decade appears to have been 42,000,000 pounds, the returns in 1890 are known to have been so incomplete that it is altogether probable that as much cheese, if not more, was then made in this country as in the year 1900 or at the present time. The total supply appears to have been at the rate of 4.1 pounds in 1890 and 3.9 pounds in 1900 per capita of the population.

The transfer of this branch of the dairy industry from farm to factory, which has been so notable from the time the associated system became known, and which has been even more marked in regard to cheese than butter, seems to be steadily progressing. The Eleventh Census gave the farm-made cheese as 7.25 per cent of the total prod-

uct, and the Twelfth Census gives this portion as only 5.5 per cent. Besides this, cheese manufacture, so far as large operations are concerned, seems to be concentrating in certain regions. The ten States reported in 1890 as leading in total cheese production were New York, Wisconsin, Ohio, Illinois, Vermont, Iowa, Pennsylvania, Michigan, California, and Minnesota. Of these the first three named still stand at the head and in the same order; all show a somewhat increased product during the decade. Pennsylvania and Michigan now come next. These five are the only States each credited with more than 10,000,000 pounds of cheese in 1900. California has the sixth place with a product of 6,916,131 pounds, which is an increase. The other four States, although following in the order above named, all show decreased production. The cheese factories in these same States in 1900 (including establishments making some butter also) numbered as follows: New York, 1,274; Wisconsin, 1,286; Ohio, 320; Pennsylvania, 140; Michigan, 135; California, 32; Illinois, 118; Vermont, 71; Iowa, 89; and Minnesota, 55; no other State had as many as 40. It is further interesting to note that Wisconsin, Pennsylvania, and California all report increased quantities of cheese made on the farm, while in all the other States named there has been a falling off in this item. California produced 4,249,588 pounds of farm-made cheese in 1900, against 2,676,543 pounds made in factories; this is the only instance of the kind and the only State reporting as much as 3,000,000 pounds made on farms. The State of Maine furnishes a good example of the changes in cheese-making which have taken place in some sections during the last quarter century. Twenty-five years ago this State had 60 cheese factories and now has 16. New York and Wisconsin continue to be the great cheese-producing States of the Union. They are credited for 1900 with totals of 130,371,034 pounds and 79,384,298 pounds, respectively. Together they produced 209,755,332 pounds, or more than two-thirds of all the cheese made in the United States.

The growth of the production of butter and cheese in the United States, as reported by the census for successive decades, together with the relative products of farms and factories, is graphically shown on Plate II, and the relative production of the several States, or of most of them, with the division into farm and factory products, may be seen by the diagram on Plate III.

AGGREGATE VALUE OF THE DAIRY PRODUCTS OF THE UNITED STATES FOR 1900.

From the foregoing statistics, including values reported or estimated for different products, the following statement of the aggregate annual value of the dairy products of the country at the time of the last census is compiled. One cent per pound, or approximately 2 cents per

quart, is assigned to the value of milk consumed as human food, and three-fourths of this for the milk fed to calves or similarly used on farms. The by-products, which constitute a considerable sum, include commercial casein and sugar of milk as principal items:

Value of dairy products, 1900.

Butter.....	\$263, 256, 852
Cheese	28, 060, 362
Condensed milk	11, 888, 792
Cream sold	4, 547, 536
Milk consumed	217, 512, 586
Milk fed to calves	39, 000, 000
By-products	41, 049, 226
Total	605, 315, 354

To this aggregate should be added the value of the calves dropped by dairy cows during the year. There were doubtless nearly 18,000,000 calves, which were fairly rated at \$1 each at time of birth. The great aggregate production of the dairy cows of the United States may therefore be placed at \$620,000,000 to \$625,000,000 per year.

THE LEADING DAIRY STATES OF THE UNION.

In making a comparison of the different States from a dairy standpoint, Iowa is conspicuous as a producer of butter, New York of cheese, Wisconsin of both butter and cheese, New York again of market milk, and Illinois of condensed milk. With regard to all dairy interests and the quantity of combined products, the number of cows kept for milk (with their relative average yield and consequently the total milk product) is the natural basis for comparison. Hence the five leading dairy States should be named in this order: New York, Iowa, Pennsylvania, Wisconsin, and Illinois. (These are also the States greatest in associated or factory dairying, but in a different order.) Iowa precedes Wisconsin by reason of its greater number of cows and aggregate production, and Pennsylvania comes before Wisconsin and Illinois because of the relatively better quality of its cows, although fewer in number. For the same reason Wisconsin, with less than 1,000,000 cows, outranks Illinois with more than 1,000,000.

The same general subject may be viewed in another way. Although a certain number of cows may be of such better capacity as to produce more milk than a larger number of animals, it is also true that a less quantity of milk and its products may have higher value than a greater quantity, by reason of accessibility to better markets. Hence a reasonable basis of comparison is the aggregate value of dairy products other than those consumed on the farms. Of these latter there are no reliable data available as to value. The values of all butter, cheese, cream, and condensed milk sold by factories, and the values of all butter and cheese sold from the farms, are given in the census

tables. By obtaining the difference between the farm sales of milk and cream and the receipts of same by all factories, the values may be found of such sales that did not enter into manufactured products previously noted. These represent approximately the values of market milk and cream. Adding these values, aggregates are obtained which represent the total products of the dairy sold from farms, as follows: New York, \$53,316,712; Pennsylvania, \$29,029,522; Wisconsin, \$25,793,002; Illinois, \$23,633,960; and Iowa, \$22,101,777. New York exceeds the other States in every item in the list and especially in its enormous sales of milk and cream for consumption in their natural form. It is this item which gives Pennsylvania the second place in this arrangement, and Illinois a position before Iowa, although the latter has 400,000 or 500,000 more cows than either of the other two.

IMPORTS AND EXPORTS OF DAIRY PRODUCTS.

Before considering the supplies of different dairy products available for consumption in the United States, it is necessary to make proper allowances for supplies imported from foreign countries and for corresponding exports. The imports and exports of these products by the United States have been extremely variable, year by year, and especially the exports. During the last half century the quantity of butter imported has ranged from 29,000 pounds in 1899 to 4,843,000 pounds in 1871. The range of exports during the same period has been from 1,324,000 pounds in 1869 to 39,236,000 pounds in 1880. A comparison of the averages by decades is more satisfactory than the selection of single years.

TABLE VII.—Imports and exports of butter by the United States.

ANNUAL AVERAGES BY DECADES.

	1850-1859.	1860-1869.	1870-1879.	1880-1889.	1890-1899.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Imports	1,321,541	3,563,542	2,161,795	569,607	100,601
Exports	3,257,404	13,960,668	11,523,252	19,769,631	18,297,057

ANNUAL AVERAGES FOR SINGLE YEARS.

	1899.	1900.	1901.	1902.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Imports	29,469	64,490	125,568	524,434
Exports	27,308,869	13,283,557	24,249,565	8,959,316

Similar statistics follow for cheese. The range of imports for fifty years has been from 334,000 pounds in 1850 to 18,875,000 pounds in 1902; and for exports 3,764,000 pounds in 1853 to 148,000,000 pounds in 1881.

TABLE VIII.—Imports and exports of cheese by the United States.

ANNUAL AVERAGES BY DECADES.

	1850-1859.	1860-1869.	1870-1879.	1880-1889.	1890-1899.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Imports	808,834	1,345,513	2,785,730	5,946,780	10,054,345
Exports	7,603,885	40,470,229	92,966,680	107,375,584	65,434,957

ANNUAL AVERAGES FOR SINGLE YEARS.

	1899.	1900.	1901.	1902.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Imports	13,167,487	14,356,983	16,188,640	18,875,740
Exports	34,646,833	54,059,049	31,396,115	19,035,438

It should be noted that the figures for imports prior to 1870 are not reliable.

Condensed milk is both imported and exported, the export trade in this commodity being of steady growth. But the Treasury Department reports values only, not quantities. The best course possible for approximating quantities is to value imports at 10 cents per pound and exports at 8 cents. Upon this estimate the following table is compiled:

TABLE IX.—Imports and exports of condensed milk.

ANNUAL AVERAGES FOR STATED DECADES.

	1870-1879.	1880-1889.	1890-1899.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Imports	362,462	3,031,471	825,390
Exports	1,382,520	2,670,001	5,166,889

ANNUAL AVERAGES FOR SINGLE CALENDAR YEARS.

	1899.	1900.	1901.	1902.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Imports	502,860	479,960	368,970	244,590
Exports	14,850,712	16,101,588	20,582,237	13,625,637

The imports of condensed milk have ranged from 182,840 pounds in 1875 to 6,691,850 pounds in 1886; the exports, from 181,450 pounds in 1864 to 20,582,237 pounds in 1901.

CONSUMPTION OF DAIRY PRODUCTS IN THE UNITED STATES.

It is a simple matter to compute the per capita consumption of butter and cheese in this country if the aggregate production as heretofore given is accepted as correct. To the aggregate of all made on farms and in factories, including urban establishments, the imports

must be added and the exports deducted. The products being reported for the calendar year of 1899, the imports and exports must be for that year also. Upon this basis the net quantity of butter available for consumption in that census year was 1,465,299,727 pounds. This provided 19.6 pounds per annum for each inhabitant, assuming the population for 1899 to have been about 75,000,000. If, without changing this last-named divisor, the estimate of the census officials is accepted or partly accepted as to butter actually made but not included in the tables, the rate of consumption per capita would be increased to approximately 20½ pounds.

In like manner the quantity of cheese found available was 278,538,146 pounds, or 3.72 pounds per capita of the population.

A similar computation may be made for condensed milk, the total quantity available being 172,647,355 pounds, or at the rate of 2.3 pounds. This result is surprising, but may be regarded as approximately correct.

In making an estimate of the consumption of natural milk the problem is more complex and factors more uncertain. The safest method is to compute the quantity of milk necessary to make all the butter, cheese, and condensed milk reported, together with allowance made for feeding calves, and find the difference between that sum and the total milk reported produced on farms, plus the estimated production by cows not on farms. The quantity of "whole" or unskimmed milk available for consumption is thus found to be 21,751,258,560 pounds, which allows 290.1 pounds per capita per annum. This is at the rate of 0.79 of 1 pound of milk per day, or a trifle less than three-fourths of a pint. To this annual allowance of natural milk per inhabitant should be added the condensed milk shown by the last paragraph to be used in this country. The 2.3 pounds of condensed milk is equivalent to 9.2 pounds of fresh milk. Therefore the per capita supply of milk just determined may be rightly increased to 299.3 pounds per year, of which over 3 per cent is in the condensed form.

An entirely independent investigation made during the past two years has determined the best possible estimates of the milk supply, and the consumption of milk per day per capita in nearly all the cities and many of the large towns of the United States. The health boards and officers and milk inspectors (where employed) have been the officials consulted. The following interesting results have been obtained:

Average estimated consumption of milk per day per capita.

	Pint.
In 38 cities having each a population exceeding 100,000.....	0.61
In 38 cities of less than 100,000 but over 50,000.....	.63
In 61 cities of less than 50,000 but over 25,000.....	.58
In 120 cities and towns of less than 25,000 inhabitants	.52

These estimates bear evidences of approximate accuracy. For various reasons the figures from the medium-sized cities are deemed more accurate than those from either the largest or the smallest. It thus appears that the probable average consumption of milk per capita in these 257 cities and towns is less than 0.6 pint per day. After careful study and numerous allowances for errors, 0.6 pint is accepted as the most accurate estimate. The population of these 257 cities aggregates 20,411,265, or more than one-fourth of the entire country. The rate of consumption by the inhabitants of towns and villages and by those of the farms—we are still considering whole, or unskimmed, milk—can not be much greater than this. Ten years ago the writer believed that the rate was but a little over one-half pint per day—perhaps 0.52 or 0.53 pint—for the entire country. At present, it is believed that 0.6 is a fair average daily rate of milk consumption for all; and yet, in concession to the opinion of others, a rate of 0.65 of a pint per day per capita is accepted as possible. This is practically the same as 0.7 pound.

ESTIMATE OF DAIRY COWS AND DAIRY PRODUCTS IN THE UNITED STATES, 1903.

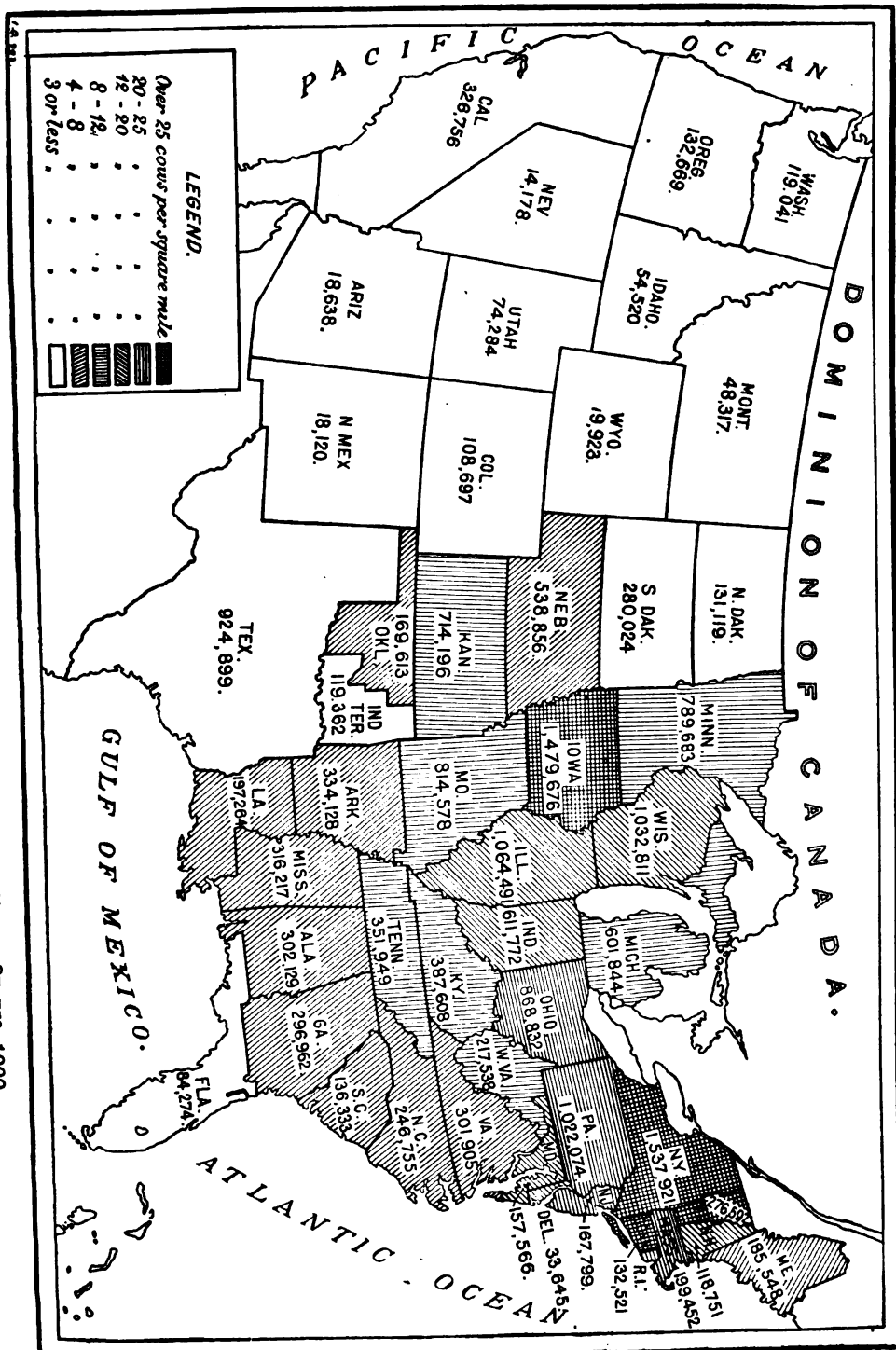
Based upon the foregoing statistics, with percentages of increase for people and for cows conservatively computed, and other modifications made for reasons explained, an estimate may be made as follows of the principal dairy data of the country for the year 1903:

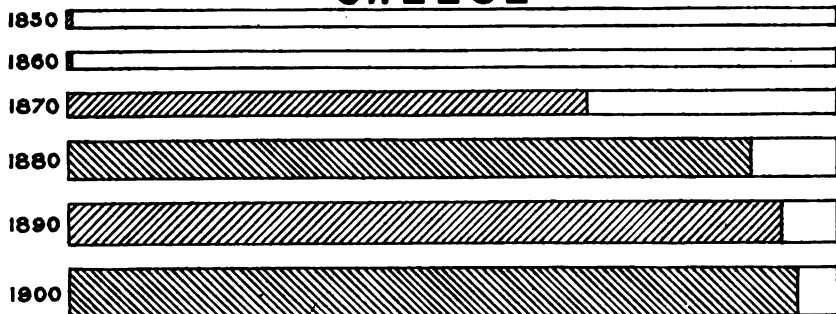
Aggregate production of milk, estimated, for 1903.

	Pounds of milk.
Product of 19,000,000 cows, at 3,560 pounds each, per annum.....	67, 640, 000, 000
Disposition of the milk product:	
1,650,000,000 pounds of butter require	38, 775, 000, 000
360,000,000 pounds of cheese require.....	3, 000, 000, 000
250,000,000 pounds of condensed milk require.....	1, 000, 000, 000
20,000,000 gallons of cream require	902, 000, 000
15,000,000 calves, estimated to consume.....	3, 139, 750, 000
81,500,000 persons, at 0.7 pound per day, will require per annum.....	20, 823, 250, 000
Total milk accounted for.....	67, 640, 000, 000

According to this statement, the cows of the United States may be arbitrarily assigned to productive duty for the year 1903 as follows:

	Cows.
For milk, condensed milk, and cream.....	6, 400, 000
For butter (151½ pounds each per year).....	10, 900, 000
For cheese (356 pounds each per year).....	840, 000
For rearing calves.....	860, 000
Total number of cows, estimated	19, 000, 000



CHEESE

THIS SURFACE REPRESENTS
50,000,000 POUNDS.

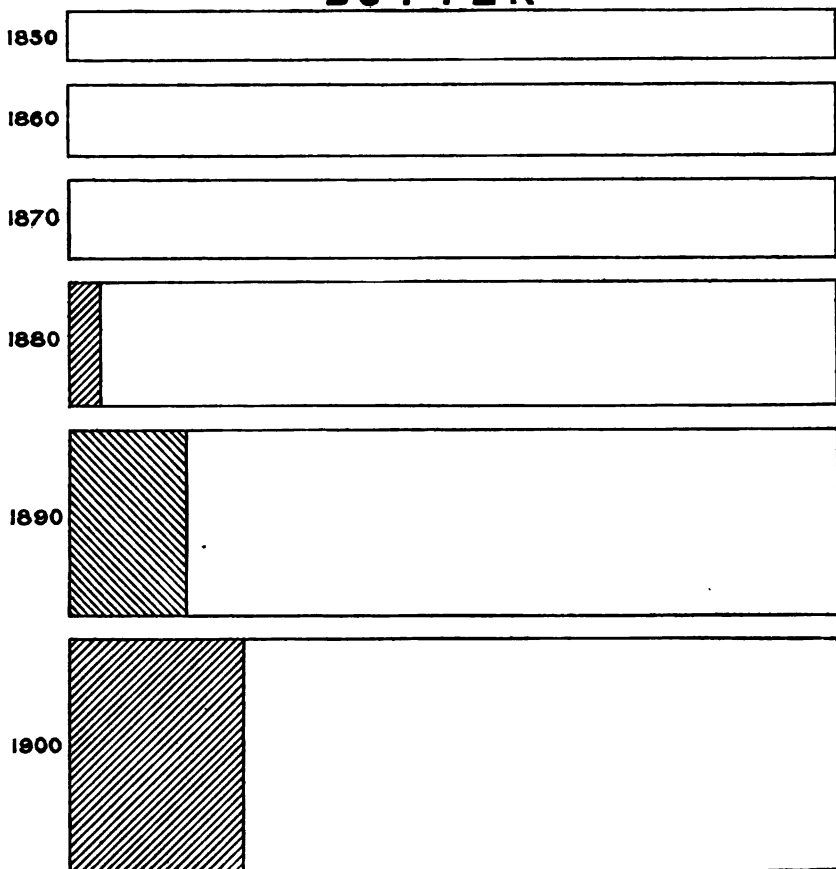
BUTTER

DIAGRAM SHOWING CHEESE AND BUTTER PRODUCTION, SIX CENSUS YEARS.
[Factory and creamery production are shaded.]

CHEESE PRODUCTION, 1900.



THIS SURFACE REPRESENTS
10,000,000 POUNDS.

BUTTER PRODUCTION, 1900.

SHADED PORTION REPRESENTS FACTORY
OR CREAMERY PRODUCT.
OPEN PORTION REPRESENTS PRODUCT
MADE ON FARMS.

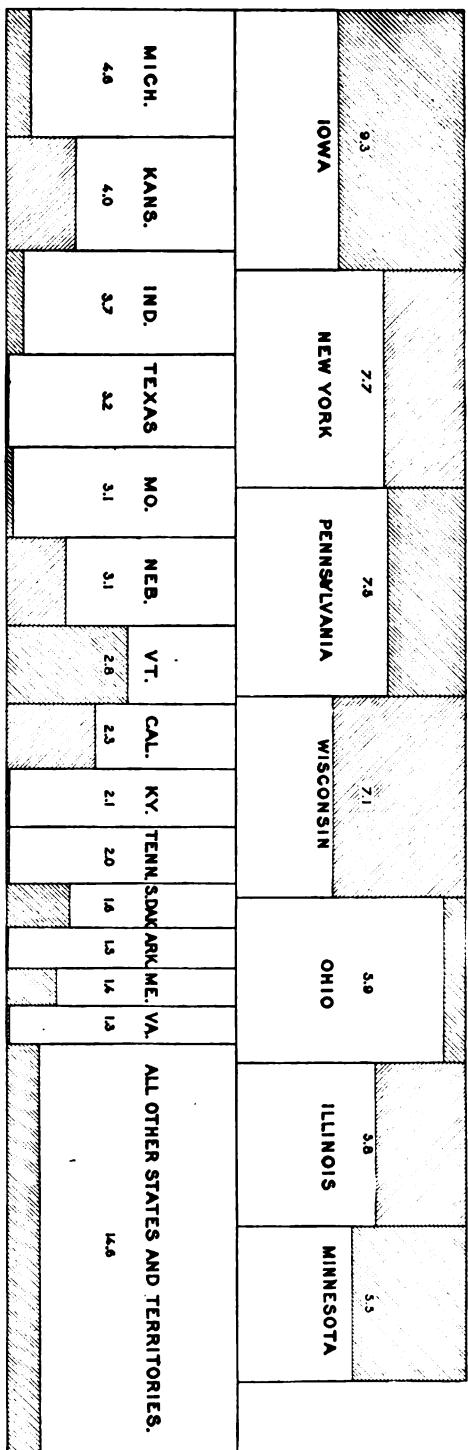


DIAGRAM SHOWING TOTAL CHEESE AND BUTTER PRODUCTION OF THE UNITED STATES IN 1900, BY STATES AND TERRITORIES, ARRANGED ACCORDING TO RANK.

[The number in the center of each subdivision denotes the percentage of the total product represented which was made in that State.]

GENERAL AGRICULTURAL STATISTICS.

TABLE X.—*Farm and dairy statistics of the United States.*

	From the United States census of—				
	1900.	1890.	1880.	1870.	1860. ^a
Population	76,303,387	62,622,250	50,155,783	38,558,371	31,443,322
Occupations:					
Total persons reported	29,285,922	22,735,661	17,392,000	.....	.....
Number in agriculture	b 10,329,764	8,466,251	7,670,493	5,922,471	3,221,574
Farms:					
Total number	5,739,764	4,564,641	4,008,907	2,659,985	2,044,077
Area, total	841,201,546	623,218,619	536,081,835	407,735,041	407,212,538
Acres unimproved, percent- age	50.7	42.6	46.9	53.7	59.9
Average size	147	137	134	153	199
Number cultivated by owner.	3,713,371	3,269,728	2,984,306	.....	.....
Number rented for money....	752,920	454,659	322,357	.....	.....
Value land and improve- ments, with buildings, etc., dollars.....	16,674,690,247	13,279,252,649	10,197,096,776	9,262,803,861	6,645,045,007
Value implements and ma- chinery.....dollars...	761,261,550	494,247,467	406,520,055	336,878,429	246,118,141
Value live stock, all kinds, dollars.....	3,078,050,041	2,208,767,573	1,500,384,707	1,525,276,457	1,089,329,915
Value farm products, an- nual ^c	4,739,118,752	2,460,107,454	2,212,540,927	2,447,538,658	.....
Cattle:					
Milch cows on farms, num- ber	d 17,139,674	16,511,950	12,443,120	8,935,332	8,585,735
All others on farms, number..	e 35,349,563	34,851,622	23,482,391	14,885,276	17,034,284
Cows to every 1,000 of population.	f 225	264	248	232	273
Milk, total produced on farms, gallons	7,266,392,674	5,209,125,567	530,129,755	235,500,599	(f)
Butter made on farms ^g ...pounds..	1,071,745,127	1,024,223,468	777,250,287	514,092,683	459,681,372
Cheese made on farms ^g ...do....	16,372,330	18,726,818	27,272,489	53,492,153	103,663,927

^aThe Seventh United States Census (1850) gives the number of milch cows 6,385,094; value of dairy products for year, \$166,193,144. The Sixth United States Census (1840) gives number of milch cows 4,837,043; value, \$72,555,000; value of dairy products for year, \$120,926,075.

^bExclusive of wood choppers, lumbermen, and raftsmen.

^cThe value of farm products for 1869 (census of 1870) included "betterments and additions to stock," so that in products only there was an actual increase in 1880 as compared with 1870. The total value of 1890, compared with 1880, showed only slight increase, although increase in the products themselves was very great; rapid decrease in market prices accounts for this difference. The great increase shown in 1900 over 1890 may doubtless be partially accounted for by more complete returns.

^dThis refers to cows on farms and ranges.

^eExclusive of 15,333,099 calves under 1 year, and 973,033 cows and 643,389 other animals not on farms and ranges.

^fNo returns of milk product were made for 1850 and 1860. The great variation in the figures given results from these facts: In 1870 only "milk sold from farms" was reported, thus omitting all consumed on farms and there made into butter and cheese; in 1880 "milk sold or sent to butter and cheese factories" was included, again excluding home consumption; in 1890 and also in 1900 the returns endeavored to show the total quantity of milk produced on farms.

^gTo butter and cheese made on farms must be added that made at creameries and cheese factories to get the total product of the country. (See Table XIII.) The progressive increase in the production of butter and cheese in the United States, and the ratio of farm and factory product, is graphically shown by Plate II.

TABLE X.—Farm and dairy statistics of the United States—Continued.

	From the United States census of—				
	1900.	1890.	1880.	1870.	1860.
Creameries, cheese factories, etc.:					
Number ^a	9,356	4,712	3,982	1,313	5
Butter made in same, bc					
pounds.....	420,964,016	181,284,916	29,421,784		
Cheese made in same, bc					
pounds.....	282,634,488	238,035,065	215,885,361	109,435,229	
Condensed milk.....pounds..	186,921,787	37,926,821	13,033,267		
Capital employed.....dollars..	36,508,015	16,624,163	9,604,808	3,690,075	13,400
Employees.....number..	15,693	14,921	7,903	4,607	13
Wages paid, annual, ^d dol-					
lars.....	6,170,670	5,390,705	1,546,496	706,566	3,060
Cost of materials.....dollars..	109,151,205	51,364,574	18,363,579	14,089,284	10,791
Value of products.....do....	131,199,277	62,686,043	25,815,963	16,771,665	23,500
Total dairy products of United					
States, ^e value.....dollars..	605,315,354	411,976,522	391,131,618	360,828,000	240,400,580

^aThe establishments reported for 1850, 1860, and 1870 were all cheese factories. The figures for 1850 are approximately correct, but those for 1860 are not; more cheese factories are known to have been in active operation in that year in the State of New York alone. The number for 1890 represents only establishments reporting; it is believed that there were over 2,000 others in operation that year.

^bTo butter and cheese made on farms must be added that made at creameries and cheese factories to get the total product of the country. (See Table XIII.) The progressive increase in the production of butter and cheese in the United States, and the ratio of farm and factory product, is graphically shown by Plate II.

^cThe butter and cheese made in creameries and factories in 1889 (census of 1890) and also in 1899 (census of 1900) does not include the products of urban establishments. (See Table XIV.)

^dThis does not include salaries, \$915,442.

^eThe total values of dairy products prior to 1900 do not include the milk of "town cows" or cows not on farms, and the amounts given are thus much below the true value.

TABLE XI.—Dairy statistics by States.

[From the Twelfth United States Census.]

States and Territories.	Dairy cows on farms, ^a	Milk produced on farms.	Butter made on farms.	Butter made at creameries.	Cheese made on farms.	Cheese made at factories.
	Number.	Gallons.	Pounds.	Pounds.	Pounds.	Pounds.
The United States..	17,139,674	7,266,392,674	1,071,745,127	420,126,546	16,372,330	281,972,324
North Atlantic Division..	3,496,266	1,827,347,473	206,284,451	119,734,095	4,509,199	143,709,072
Maine.....	173,592	99,586,188	16,174,173	4,461,399	425,102	553,946
New Hampshire.....	115,036	60,724,590	6,385,611	5,034,270	104,389	116,741
Vermont.....	270,194	142,042,223	18,834,706	22,453,381	406,659	4,713,105
Massachusetts.....	184,562	105,571,873	4,980,262	4,591,919	19,629	250,542
Rhode Island.....	23,660	12,923,512	488,086	148,195	6,751	
Connecticut.....	126,434	68,951,862	4,591,789	3,888,405	40,623	321,263
New York.....	1,501,608	772,799,352	74,714,376	40,693,846	2,624,562	127,386,032
New Jersey.....	157,407	77,714,055	5,894,363	1,325,519	24,377	100,000
Pennsylvania.....	943,773	487,033,818	74,221,085	37,137,161	857,167	10,267,443
South Atlantic Division..	1,383,319	492,138,465	89,111,226	3,772,086	480,448	112,860
Delaware.....	32,591	12,681,268	1,629,949	969,889	104	15,000
Maryland.....	147,284	64,040,517	9,096,662	2,541,716	338,453	
District of Columbia..	1,251	850,349	3,478			
Virginia.....	281,876	105,068,428	19,905,830	170,521	31,697	57,000
West Virginia.....	205,601	83,861,660	16,913,129	41,000	74,243	40,860
North Carolina.....	233,178	89,525,749	16,913,802		28,888	

^a Does not include 973,033 cows not on farms and ranges.

TABLE XI.—*Dairy Statistics by States—Continued.*

States and Territories.	Dairy cows on farms.	Milk produced on farms.	Butter made on farms.	Butter made at creameries.	Cheese made on farms.	Cheese made at factories.
South Atlantic Division—Continued.	<i>Number.</i>	<i>Gallons.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
South Carolina.....	126,684	44,081,528	8,150,437	.....	1,081	.....
Georgia.....	276,024	82,438,532	15,111,494	48,960	2,236	.....
Florida.....	78,830	9,640,434	1,386,445	.....	3,751	.....
North Central Division.....	8,430,234	3,609,900,323	539,104,750	271,736,947	5,320,122	128,625,971
Ohio.....	818,239	425,870,394	79,551,299	8,087,631	1,167,001	18,156,527
Indiana.....	574,276	263,457,239	51,042,396	3,553,483	178,733	1,260,168
Illinois.....	1,007,664	457,106,995	52,493,450	34,055,312	323,485	9,055,119
Michigan.....	563,905	309,617,046	60,051,998	7,820,712	331,176	10,422,582
Wisconsin.....	998,397	472,274,264	44,739,147	61,813,502	1,635,618	77,748,680
Minnesota.....	753,632	304,017,106	41,188,846	41,174,469	290,623	3,285,019
Iowa.....	1,423,648	535,872,240	61,789,288	77,233,264	306,428	4,242,637
Missouri.....	765,386	258,207,755	45,509,110	1,440,616	323,439	1,072,751
North Dakota.....	125,503	48,845,280	9,178,815	463,188	70,881	225,399
South Dakota.....	270,634	99,244,975	17,400,970	6,172,107	136,863	420,779
Nebraska.....	512,544	190,477,911	34,518,659	11,726,180	264,430	313,600
Kansas.....	676,456	244,909,123	41,640,772	18,196,483	291,445	2,422,710
South Central Division.....	2,899,236	973,950,188	185,923,330	932,857	473,440	181,469
Kentucky.....	864,025	159,311,527	30,446,381	184,668	45,759	28,000
Tennessee.....	321,676	147,336,961	29,091,696	207,823	26,622	6,201
Alabama.....	279,268	95,882,103	19,121,964	17,357	36,374	10,000
Mississippi.....	299,318	97,030,385	18,881,236	48,525	28,572	.....
Louisiana.....	184,815	39,251,413	4,918,229	.....	135,104	.....
Texas.....	861,023	251,342,698	47,991,492	252,714	136,133	58,290
Oklahoma.....	165,852	47,439,853	8,781,359	53,200	45,264	66,378
Indian Territory.....	110,687	26,493,855	5,105,715	.....	1,227	.....
Arkansas.....	312,577	109,861,393	21,585,258	168,575	18,385	12,600
Western Division.....	866,528	362,467,850	51,202,299	23,950,561	5,589,109	9,342,952
Montana.....	45,036	15,696,214	2,454,072	34,238	30,924	.....
Wyoming.....	18,272	5,121,974	888,554	29,500	24,327	1,000
Colorado.....	100,116	38,440,111	4,932,482	1,566,639	103,184	1,465,257
New Mexico.....	16,775	3,009,657	313,003	.....	68,571	.....
Arizona.....	17,965	3,056,109	379,311	424,083	33,305	373,752
Utah.....	65,905	25,124,642	2,812,122	2,519,214	169,251	1,874,179
Nevada.....	13,606	4,446,071	569,523	623,402	94,082	80,150
Idaho.....	51,929	15,122,948	2,520,316	432,570	196,952	194,380
Washington.....	107,232	50,182,415	7,372,106	3,198,421	151,669	1,482,127
Oregon.....	122,447	48,582,968	8,107,450	1,975,357	467,256	1,195,564
California.....	307,245	158,684,741	20,853,360	13,147,137	4,249,588	2,676,543
Alaska.....	13	4,250	200	.....	.....	.....
Hawaii.....	4,028	584,120	118,871	.....	12	.....

TABLE XII.—Progress of dairying in the United States, 1850 to 1900.^a

[United States Census statistics.]

States and Territories.	Year of census.	Dairy cows on farms.		Milk, product reported.	Butter, total made.	Cheese, total made.	Creameries and cheese factories.	Milk, average yield per cow.
		Total number.	Per 1,000 persons.					
				Gallons.	Pounds.	Pounds.	Number.	Gallons.
United States...	1900	17,139,674	225	7,266,392,674	1,491,871,673	298,344,654	9,355	424
	1890	16,511,950	264	5,209,125,567	1,205,508,384	256,761,883	b 4,712	315
	1880	12,443,120	248	c 530,129,755	806,672,071	243,157,850	3,932	233
	1870	8,935,332	232	d 235,500,599	514,092,683	162,927,382	e 1,313	206
	1860	8,585,785	273	Not given.	459,681,372	108,663,927	e 5	175
	1850	6,385,094	275	Not given.	313,345,306	105,535,893	e 8	167
North Atlantic Division	1900	3,496,266	166	1,827,347,473	326,018,546	148,218,271	3,230	523
	1890	3,351,061	193	1,435,739,255	295,063,716	139,238,694	1,971	428
	1880	3,190,745	220	c 345,749,869	277,008,072	150,902,229	1,975	.....
	1870	2,833,022	230	d 186,605,146	225,910,518	35,144,853	e 913	.....
	1860	2,615,929	.....	.....	223,950,757	72,860,013	.....	.....
	1850	2,188,503	.....	.....	173,065,728	79,731,981	.....	.....
Maine	1900	173,592	250	99,586,188	20,635,572	979,048	61	574
	1890	157,278	238	57,969,791	16,999,356	1,451,813	42	369
	1880	150,845	232	c 3,720,793	14,109,966	1,945,095	41	314
	1870	139,259	222	d 1,374,091	11,636,482	1,152,590	0	270
	1860	147,314	235	.....	11,687,781	1,799,862	.....	252
	1850	133,556	229	.....	9,243,811	2,434,454	.....	229
New Hampshire...	1900	115,036	279	60,724,590	11,419,881	221,080	53	528
	1890	109,423	290	42,633,268	9,862,430	444,623	23	390
	1880	90,564	261	c 5,739,128	7,346,340	807,076	2	314
	1870	90,583	285	d 2,352,884	5,965,080	872,368	e 2	235
	1860	94,890	291	.....	6,956,764	2,232,092	.....	247
	1850	94,277	265	.....	6,977,066	3,196,563	.....	262
Vermont	1900	270,194	786	142,042,223	41,288,087	5,119,764	255	526
	1890	231,419	697	90,712,230	23,399,440	6,191,913	124	393
	1880	217,033	654	c 6,526,550	25,252,663	6,129,879	85	387
	1870	180,285	545	d 3,835,840	17,844,396	7,814,879	e 28	350
	1860	174,667	554	.....	15,900,359	8,215,030	.....	328
	1850	146,128	465	.....	12,137,980	8,720,834	.....	319
Massachusetts...	1900	184,562	66	105,571,873	9,572,181	270,171	51	572
	1890	172,046	77	82,571,924	10,410,300	385,533	37	480
	1880	150,435	84	c 29,662,953	9,799,804	2,201,393	22	396
	1870	114,771	79	d 15,284,057	6,569,161	4,131,359	e 23	327
	1860	144,492	117	.....	8,297,936	5,294,090	.....	215
	1850	130,099	131	.....	8,071,370	7,088,142	.....	250
Rhode Island....	1900	23,660	55	12,923,512	636,281	6,751	3	546
	1890	23,943	69	10,610,547	1,199,239	324,631	4	443
	1880	21,460	78	c 3,831,706	1,007,103	67,171	0	323
	1870	18,906	87	d 1,944,044	941,199	81,976	0	259
	1860	19,700	113	.....	1,021,767	181,511	.....	166
	1850	18,698	126	.....	995,670	316,508	.....	180
Connecticut	1900	126,434	139	68,951,862	8,480,194	361,886	72	545
	1890	127,892	171	54,413,822	10,369,259	308,521	50	425

^a Does not include the products from cows in barns and inclosures.^b See note *b* of Table X.^c "Milk sold or sent to butter and cheese factories, gallons," census, 1880.^d "Milk sold from farms, gallons," census, 1870.^e Cheese factories only.

TABLE XII.—*Progress of dairying in the United States, 1850 to 1900—Continued.*

States and Territories.	Year of census.	Dairy cows on farms.		Milk product reported.	Butter, total made.	Cheese, total made.	Creameries and cheese factories.	Milk, average yield per cow.
		Total number.	Per 1,000 persons.					
North Atlantic Division—Continued.								
Connecticut.....	1880	116,319	187	<i>Gallons.</i> a 12,289,893	<i>Pounds.</i> 8,418,906	<i>Pounds.</i> 1,051,677	<i>Number</i> 16	<i>Gallons.</i> 325
	1870	98,889	184	b 6,253,259	6,716,007	2,262,894	c 7	291
	1860	98,877	215	.....	7,620,912	8,898,411	.....	277
	1850	85,461	280	.....	6,498,119	5,368,277	.....	301
New York.....	1900	1,501,608	207	772,799,352	115,408,222	130,010,584	1,928	515
	1890	1,440,230	240	663,917,240	112,727,515	124,066,524	1,837	461
	1880	1,437,855	283	a 231,965,533	120,878,201	129,163,714	1,652	402
	1870	1,350,661	308	b 135,775,919	107,147,526	100,776,012	c 818	356
New Jersey.....	1860	1,123,634	290	.....	108,097,250	48,548,289	.....	326
	1850	931,324	301	.....	79,766,094	49,741,413	.....	319
	1900	157,407	84	77,714,055	7,219,882	124,377	53	494
	1890	161,576	112	64,003,953	8,866,749	567,241	16	396
Pennsylvania...	1880	152,078	134	a 15,472,783	9,872,237	569,736	11	290
	1870	133,331	147	b 5,373,323	8,266,023	478,336	c 8	227
	1860	138,818	207	.....	10,714,447	182,172	.....	233
	1850	118,736	242	.....	9,487,210	365,756	.....	243
South Atlantic Division.....	1900	943,773	150	487,033,818	111,858,246	11,124,610	754	516
	1890	927,254	176	368,906,480	96,199,428	5,457,897	338	396
	1880	854,156	199	a 36,540,540	80,322,852	8,966,737	146	323
	1870	706,437	201	b 14,411,729	60,834,644	2,792,676	c 27	281
Delaware.....	1860	673,547	232	.....	58,653,511	2,508,566	.....	266
	1850	530,224	229	.....	39,878,418	2,506,034	.....	231
	1900	1,888,319	132	492,138,465	92,883,312	598,308	129	356
	1890	1,869,466	155	331,728,677	80,414,839	415,291	50	242
Maryland.....	1880	1,280,761	169	a 9,446,511	48,703,330	640,065	31	.....
	1870	1,001,094	171	b 3,187,589	28,575,306	190,890	c 5	.....
	1860	1,238,633	.....	.....	33,941,403	369,302	.....	.....
	1850	1,246,678	.....	.....	28,105,896	610,836	.....	.....
Dist. Columbia..	1900	32,591	176	12,681,268	2,599,838	15,104	22	389
	1890	32,574	194	10,699,362	2,493,259	359	6	328
	1880	27,284	186	a 1,132,434	1,902,075	1,712	3	248
	1870	24,082	192	b 758,603	1,171,963	315	0	178
Virginia.....	1860	22,595	202	.....	1,430,502	6,579	.....	190
	1850	19,218	209	.....	1,055,308	3,187	.....	165
	1900	147,284	124	64,040,517	11,638,378	338,453	88	435
	1890	142,198	136	46,601,218	10,846,879	23,573	24	328
North Carolina.....	1880	122,907	131	a 4,722,944	7,715,196	79,416	14	221
	1870	94,794	121	b 1,520,101	5,014,729	6,732	0	175
	1860	99,463	145	.....	5,265,295	8,342	.....	159
	1850	86,856	149	.....	3,806,160	3,975	.....	132
South Carolina.....	1900	1,251	4	850,349	3,478	.....	.....	680
	1890	863	4	459,978	13,769	.....	4	533
	1880	1,292	7	a 496,789	88,520	155,460	1	433
	1870	657	5	b 126,077	4,495	.....	0	212
Georgia.....	1860	639	9	.....	18,835	.....	.....	88
	1850	813	16	.....	14,872	1,500	.....	57

a "Milk sold or sent to butter and cheese factories, gallons," census, 1880.

b "Milk sold from farms, gallons," census 1870.

c Cheese factories only.

TABLE XII.—*Progress of dairying in the United States, 1850 to 1900—Continued.*

[United States Census statistics.]

States and Territories.	Year of census.	Dairy cows on farms.		Milk, product reported.	Butter, total made.	Cheese.	Creameries and cheese factories.	Milk, average yield per cow.
		Total number.	Per 1,000 persons.					
South Atlantic Division—Continued.								
Virginia.....	1900	281,876	152	<i>Gallons.</i> 105,068,428	<i>Pounds.</i> 20,076,351	<i>Pounds.</i> 88,697	<i>Number</i> 10	<i>Gallons.</i> 373
	1890	273,634	165	78,143,459	18,761,856	218,187	13	286
	1880	243,061	161	a 1,224,469	11,500,023	111,535	4	147
	1870	188,471	154	b 266,812	6,979,269	64,243	c 2	113
	1860	330,713	207	.....	13,464,722	280,852	.....	123
West Virginia..	1850	317,619	223	.....	11,089,359	436,292	.....	106
	1900	205,601	214	83,861,660	16,954,129	115,103	5	408
	1890	188,492	247	59,449,066	14,081,627	95,372	3	315
	1880	166,966	254	a 750,279	9,309,517	196,987	7	184
North Carolina..	1870	104,434	236	b 144,835	5,044,475	32,429	0	147
	1900	233,178	123	89,525,749	16,913,802	28,883	.....	384
	1890	223,416	138	55,250,665	13,129,374	60,760	0	247
	1880	232,133	166	a 446,798	7,213,507	57,380	2	95
	1870	196,731	184	b 17,145	4,297,834	123,985	c 3	66
South Carolina..	1860	228,623	230	.....	4,785,495	51,119	.....	62
	1850	221,799	255	.....	4,146,290	95,921	.....	57
	1900	126,684	95	44,031,528	8,150,437	1,081	.....	348
	1890	107,184	93	23,833,631	5,737,557	2,476	0	222
	1880	139,881	140	a 257,186	3,196,851	16,018	0	71
Georgia.....	1870	98,693	140	b 241,815	1,461,980	169	0	47
	1860	163,938	233	.....	3,177,934	1,543	.....	58
	1850	193,244	289	.....	2,981,850	4,970	.....	46
	1900	276,024	125	82,438,532	15,160,454	2,236	4	299
	1890	287,717	157	52,234,508	14,483,323	12,833	0	182
Florida.....	1880	315,073	204	a 374,645	7,424,485	19,151	0	72
	1870	231,310	195	b 109,139	4,499,572	4,292	0	59
	1860	299,688	284	.....	5,439,765	15,587	.....	55
	1850	334,223	369	.....	4,640,559	46,976	0	42
	1900	78,830	149	9,640,434	1,386,445	3,751	.....	122
North Central Division.....	1890	113,388	290	5,056,790	867,195	1,731	0	45
	1880	42,174	157	a 40,967	353,156	2,406	0	26
	1870	61,922	329	b 3,002	100,989	25	0	5
	1860	92,974	664	.....	408,855	5,280	.....	13
	1850	72,876	838	.....	371,498	18,015	.....	16
Ohio.....	1900	8,490,284	322	3,609,900,328	810,841,697	133,946,093	5,481	425
	1890	8,240,999	369	2,719,414,765	650,551,544	110,225,861	2,617	318
	1880	5,402,081	311	a 155,044,519	383,435,099	86,532,570	1,648	.....
	1870	3,294,007	254	b 38,853,454	214,400,425	14,178,005	388	.....
	1860	2,556,536	.....	.....	153,071,558	28,238,411	.....	.....
Ohio.....	1850	1,564,219	.....	.....	80,563,732	24,547,518	.....	.....
	1900	818,239	197	425,870,894	87,638,930	19,323,528	484	520
	1890	794,833	216	326,925,396	81,522,792	22,254,054	361	411
	1880	767,043	240	a 46,801,537	69,722,506	32,531,683	452	329
	1870	654,390	246	b 22,275,344	50,266,372	24,153,876	195	279
Ohio.....	1860	676,585	289	.....	48,543,162	21,618,893	.....	253
	1850	544,499	275	.....	34,449,379	20,819,542	.....	234

a "Milk sold or sent to cheese and butter factories, gallons," census, 1880.

b "Milk sold from farms, gallons," census, 1870.

c Cheese factories only.

TABLE XII.—*Progress of dairying in the United States, 1850 to 1900—Continued.*

States and Territories.	Year of census.	Dairy cows on farms.		Milk, product reported.	Butter, total made.	Cheese, total made.	Creameries and cheese factories.	Milk, average yield per cow.
		Total number.	Per 1,000 persons.					
North Central Division—Continued.								
Indiana				Gallons.	Pounds.	Pounds.	Number	Gallons.
	1900	574,276	228	263,457,239	54,595,879	1,438,901	113	450
	1890	579,287	264	200,510,797	50,154,854	1,191,500	55	346
	1880	494,944	250	a 6,723,840	37,712,316	1,676,825	49	241
	1870	393,736	234	b 986,963	22,915,885	391,487	17	179
	1860	363,553	269	.....	18,306,651	605,795	.....	153
Illinois	1850	284,564	288	.....	12,881,535	624,564	.....	138
	1900	1,007,664	209	457,106,995	86,548,762	9,378,604	534	454
	1890	1,067,886	264	367,269,464	82,674,908	10,348,933	266	338
	1880	865,913	281	a 45,419,719	60,208,972	21,253,194	285	240
	1870	640,321	252	b 9,258,545	36,083,405	5,734,004	69	187
	1860	522,634	305	.....	28,052,551	1,848,557	.....	165
Michigan	1850	294,671	346	.....	12,526,543	1,278,225	.....	138
	1900	563,906	233	309,617,046	67,872,710	10,753,758	290	549
	1890	497,611	238	224,537,488	52,843,212	5,370,460	101	451
	1880	384,578	235	a 7,896,273	38,865,106	3,963,585	74	325
	1870	250,859	127	b 2,277,122	24,400,185	2,301,801	30	304
	1860	179,543	240	.....	15,503,482	1,641,897	.....	270
Wisconsin	1850	99,676	250	.....	7,065,878	1,011,492	.....	225
	1900	996,397	483	472,274,264	106,552,649	79,384,296	2,019	473
	1890	792,620	470	303,701,134	60,355,499	54,614,861	966	383
	1880	478,374	364	a 25,156,977	33,842,336	19,535,324	414	267
	1870	308,377	292	b 2,059,105	22,473,036	3,288,581	54	231
	1860	203,001	262	.....	13,611,328	1,104,300	.....	208
Minnesota	1850	64,339	211	.....	3,633,750	400,283	.....	177
	1900	753,632	430	304,017,106	82,363,315	3,575,642	596	403
	1890	593,908	456	182,968,973	48,677,504	4,292,170	115	308
	1880	275,545	353	a 1,504,407	19,244,835	985,329	27	216
	1870	121,467	276	b 208,130	9,522,010	271,477	2	239
	1860	40,344	235	.....	2,957,673	199,314	.....	226
Iowa	1850	607	101	.....	1,100	.....	.....	5
	1900	1,423,648	638	535,872,240	139,022,532	4,549,065	907	376
	1890	1,498,418	784	486,961,411	126,036,219	5,743,934	500	325
	1880	854,187	526	a 15,965,612	61,665,071	3,852,801	244	215
	1870	369,811	310	b 688,800	27,512,179	1,344,647	14	229
	1860	189,802	281	.....	11,953,666	918,635	.....	195
Missouri	1850	45,704	238	.....	2,171,188	209,840	.....	148
	1900	765,386	246	258,207,755	46,949,726	1,396,190	115	337
	1890	851,076	318	193,931,103	44,638,168	1,673,017	68	228
	1880	661,405	305	a 3,173,017	28,712,988	873,549	30	135
	1870	398,515	232	b 857,704	14,455,825	213,865	1	112
	1860	345,243	292	.....	12,704,837	259,633	.....	111
North Dakota	1850	230,169	337	.....	7,834,359	203,572	.....	108
	1900	125,503	393	48,845,280	9,642,003	296,280	21	389
	1890	88,289	482	26,566,112	6,158,862	180,374	10	301
South Dakota	1900	270,634	674	99,244,975	23,573,077	557,642	138	367
	1890	210,240	639	59,666,525	13,659,757	554,763	16	284

a "Milk sold or sent to butter and cheese factories, gallons," census, 1880,

b "Milk sold from farms, gallons," census, 1870.

TABLE XII.—*Progress of dairying in the United States, 1850 to 1900—Continued.*

States and Territories.	Year of census.	Dairy cows on farms.		Milk product reported.	Butter, total made.	Cheese, total made.	Creameries and cheese factories.	Milk, average yield per cow.
		Total number.	Per 1,000 persons.					
North Central Division—Continued.								
Dakota Territory	1880	40,572	301	Gallons. a 415,119	Pounds. 2,006,755	Pounds. 40,137	Number 4	Gallons. 159
	1870	4,151	297	.....	209,735	1,850	0	152
	1860	286	57	.....	2,170	.....	.....	23
Nebraska	1900	512,544	481	190,477,911	46,244,839	578,030	93	372
	1890	505,045	477	144,768,263	33,894,861	1,268,449	58	287
	1880	161,187	357	a 625,783	9,790,970	554,772	21	187
Kansas	1870	28,940	235	b 95,059	1,539,535	78,542	5	165
	1860	6,995	241	.....	342,541	12,342	.....	149
	1900	676,456	460	244,909,123	59,837,255	2,714,155	171	362
South Central Division	1890	741,786	520	201,608,099	50,434,952	2,733,346	101	272
	1880	418,333	420	a 1,360,235	21,683,244	1,275,371	48	160
	1870	123,440	339	b 196,662	5,022,758	241,607	1	126
Kentucky	1860	28,550	267	.....	1,093,497	29,046	.....	116
	1900	2,899,236	206	973,950,188	186,856,187	654,909	71	336
	1890	2,829,657	258	519,693,663	135,302,951	349,667	22	184
Tennessee	1880	2,147,440	241	a 6,084,788	74,206,771	276,923	10	.....
	1870	1,494,434	232	b 2,811,323	34,062,404	311,498	4	.....
	1860	1,859,117	.....	.....	44,132,365	644,416	.....	.....
Alabama	1850	1,356,491	.....	.....	31,324,361	571,562	.....	.....
	1900	364,025	170	159,311,527	30,631,044	73,759	27	438
	1890	364,516	196	118,497,289	29,038,406	64,822	15	325
Mississippi	1880	301,882	183	a 2,513,209	18,261,004	58,468	8	190
	1870	247,615	187	b 1,345,779	11,874,978	861,219	4	150
	1860	269,215	233	.....	11,716,609	190,400	.....	131
Louisiana	1850	247,475	252	.....	9,947,523	213,954	.....	122
	1900	321,676	159	147,336,961	29,299,519	32,823	13	458
	1890	345,311	195	107,657,116	28,380,377	101,219	4	312
Arkansas	1880	308,900	197	a 1,006,795	17,889,969	107,740	2	180
	1870	243,197	193	b 415,786	9,571,069	142,240	0	121
	1860	249,514	225	.....	10,017,787	135,575	.....	121
Texas	1850	250,456	250	.....	8,139,585	177,681	.....	98
	1900	279,263	153	95,882,103	19,139,321	46,374	4	343
	1890	292,088	193	55,508,687	14,548,435	6,131	0	190
Oklahoma	1880	271,443	215	a 267,387	7,997,719	14,091	0	89
	1870	170,640	171	b 104,657	3,213,753	2,732	.....	57
	1860	230,537	239	.....	6,028,478	15,923	.....	79
Idaho	1850	227,791	295	.....	4,008,811	31,412	.....	53
	1900	299,318	198	97,030,385	18,923,761	28,572	2	324
	1890	310,159	240	50,803,371	12,988,637	4,898	0	164
Montana	1880	268,178	237	a 427,492	7,454,657	4,239	0	85
	1870	173,899	210	b 17,052	2,613,521	3,099	0	45
	1860	207,646	263	.....	5,006,610	4,427	.....	72
Wyoming	1850	214,231	353	.....	4,346,234	21,191	.....	61
	1900	184,815	134	39,251,413	4,918,229	135,104	0	212
	1890	167,223	149	12,881,927	2,089,774	3,939	0	77
New Mexico	1880	146,454	156	a 256,241	916,089	7,618	0	21
	1870	102,076	140	b 833,928	322,405	11,747	0	18

a "Milk sold or sent to butter and cheese factories, gallons," census, 1880.
 b "Milk sold from farms, gallons," census, 1870.

TABLE XII.—*Progress of dairying in the United States, 1850 to 1900—Continued.*

States and Territories.	Year of census.	Dairy cows on farm.		Milk product reported.	Butter, total made.	Cheese, total made.	Creameries and cheese factories.	Milk, average yield per cow.
		Total number.	Per 1,000 persons.					
South Central Division—Continued.				Gallons.	Pounds.	Pounds.	Number	Gallons.
Louisiana	1860	129,662	183	.....	1,444,742	6,158	.....	34
	1850	106,576	204	.....	683,069	1,957	.....	19
Texas	1900	861,023	282	251,342,698	48,244,206	194,423	12	292
	1890	1,003,439	449	118,475,320	32,145,249	145,730	3	118
	1880	606,176	381	a 1,296,806	13,899,320	58,466	0	71
	1870	428,048	523	b 62,771	3,712,747	34,342	0	26
	1860	601,540	996	.....	5,850,583	275,128	.....	30
	1850	217,811	1,023	.....	2,344,900	95,299	.....	33
Oklahoma	1900	165,852	416	47,439,853	8,834,559	111,642	5	286
	1890	16,756	270	1,544,280	387,920	1,600	0	92
Indian Territory.	1900	110,687	282	26,493,855	5,105,715	1,227	.....	239
Arkansas	1900	312,577	238	109,861,393	21,753,833	30,945	8	351
	1890	330,165	293	54,325,673	15,724,144	21,828	0	165
	1880	249,407	311	a 316,858	7,790,013	26,301	0	95
	1870	128,959	266	b 31,350	2,753,931	2,119	.....	64
	1860	171,003	393	.....	4,067,556	16,810	.....	72
	1850	93,151	444	.....	1,854,239	30,088	.....	60
Western Division....	1900	866,528	212	362,467,850	75,152,860	14,932,061	444	418
	1890	720,767	238	202,549,207	44,166,290	6,519,870	52	231
	1880	422,093	239	a 13,804,068	23,296,799	4,806,063	268	.....
	1870	312,775	316	b 4,043,087	11,144,030	3,666,907	3	.....
	1860	315,520	.....	.....	4,585,289	1,551,785	.....	.....
	1850	29,203	.....	.....	295,589	73,976	.....	.....
Montana	1900	45,036	185	15,696,214	2,488,310	30,924	3	349
	1890	24,143	183	6,038,096	1,062,185	11,512	1	250
	1880	11,308	290	a 41,165	412,738	80,070	3	117
	1870	12,432	592	b 105,186	408,080	27,603	1	109
Wyoming	1900	18,272	197	5,121,974	918,054	25,327	2	280
	1890	11,684	192	3,064,588	428,269	15,196	1	262
	1880	3,730	178	a 75,343	105,643	2,930	0	106
	1870	707	79	b 4,980	1,200	.....	0	12
Colorado	1900	100,116	186	38,440,111	6,499,121	1,568,441	38	334
	1890	76,948	187	19,680,791	3,621,086	131,683	6	256
	1880	28,770	148	a 506,706	862,479	75,367	2	108
	1870	25,017	625	b 19,520	392,920	37,626	1	50
New Mexico.....	1900	16,775	86	3,009,657	313,003	68,571	0	179
	1890	18,507	120	717,155	860,042	18,931	0	39
	1880	12,955	108	a 10,036	44,827	10,501	0	12
	1870	16,417	178	b 813	12,912	27,239	0	4
	1860	34,369	366	.....	13,259	37,240	.....	2
	1850	10,635	172	.....	111	5,848	.....	1
Arizona	1900	17,965	146	3,056,109	803,394	407,057	7	170
	1890	4,874	81	709,225	115,203	10,855	0	146
	1880	9,156	229	a 42,618	62,217	62,217	2	27
	1870	938	94	b 4,800	800	14,500	0	26
Utah	1900	65,905	238	25,124,642	5,331,336	2,043,430	57	331
	1890	45,982	221	8,614,694	1,815,154	176,739	3	187
	1880	32,768	228	a 155,263	1,064,923	266,749	11	106

a "Milk sold or sent to butter and cheese factories, gallons," census 1880.

b "Milk sold from farms, gallons," census 1870.

TABLE XII.—*Progress of dairying in the United States, 1850 to 1900—Continued.*

States and Territories.	Year of census.	Dairy cows on farm.		Milk product reported.	Butter, total made.	Cheese, total made.	Creameries and cheese factories.	Milk, average yield per cow.
		Total number.	Per 1,000 persons.					
Western division—Continued.				Gallons.	Pounds.	Pounds.	Number	Gallons.
Utah	1870	17,563	202	a 11,240	310,335	69,608	0	58
	1880	11,967	299		316,046	53,331		84
	1890	4,861	442		83,309	30,998		59
Nevada	1900	13,606	321	4,446,071	1,192,925	174,232	4	327
	1890	9,273	202	2,532,052	489,657	51,207	1	273
	1880	13,319	215	b 149,889	338,688	17,420	2	88
	1870	6,174	147	a 63,850	110,880		0	64
	1860	947	135		7,700			24
Idaho	1900	51,929	321	15,122,948	2,952,886	391,332	19	291
	1890	27,278	325	5,085,863	1,091,753	323,853	4	186
	1880	12,838	389	b 15,627	314,244	117,295	6	76
	1870	4,171	278	a 11,250	111,480	4,464	0	84
Washington	1900	107,232	207	50,182,415	10,570,527	1,633,796	60	468
	1890	70,721	203	19,873,281	3,483,725	820,981	3	281
	1880	27,622	368	b 226,703	1,404,066	179,200	2	160
	1870	16,938	706	a 21,060	407,306	17,465	0	75
	1860	9,660	806		153,092	12,146		49
Oregon	1900	122,447	296	48,582,968	10,082,807	1,662,820	68	397
	1890	114,156	363	25,042,276	4,924,745	496,116	12	219
	1880	59,549	340	b 227,540	2,528,225	299,732	24	130
	1870	48,325	531	a 107,367	1,418,373	119,383	1	92
	1860	53,170	1,022		1,000,157	105,379		59
	1850	9,427	725		211,464	36,980		72
California	1900	307,245	207	153,684,741	34,000,497	6,926,131	186	500
	1890	317,201	263	111,191,186	27,018,171	4,962,797	21	351
	1880	210,078	243	b 12,353,178	16,158,749	3,720,739	216	274
	1870	164,093	293	a 3,693,021	7,969,744	3,395,074	0	192
	1860	205,407	541		3,095,035	1,343,689		53
	1850	4,280	46		705	150		1

a "Milk sold from farms, gallons," census 1870.

b "Milk sold or sent to butter and cheese factories, gallons," census 1880.

NOTE.—Table XII is taken entire from census reports excepting the last column. In that the figures for 1890 and 1900 are computed from the census, and those for the other years are quoted from reports of the Department of Agriculture.

The column of "average milk yield per cow" shows an increase, decade after decade, which indicates a rapid improvement in cows. But these figures are misleading, because their basis varies for different years. In the earlier censuses the milk yield was not reported. For 1850 and 1860 only the butter and cheese made on farms were given, and the average milk yield per cow estimated erroneously by reducing the reported products to an equivalent in milk and dividing by the number of cows. The cows were thus credited with only such milk as was made into butter and cheese. For 1870 and 1880 the same plan was followed, but milk sold being also reported, this was added to that manufactured on farms; the large quantity of milk consumed on farms was still omitted from the computation. For 1890 the census reported the total milk product for the first time; this being directly divided by the number of producing cows, apparently gives the annual average yield per cow. This subject is discussed on page 17.

TABLE XIII.—*Dairying in the United States for 1900.*^a

[Includes estimated product from 973,038 cows not on farms and ranges, and butter and cheese made at urban establishments.]

States and Territories.	Dairy cows in United States.		Milk product reported plus estimated milk.	Total butter made.	Total cheese made.
	Total number.	Per 1,000 persons.			
			<i>Gallons.</i>	<i>Pounds.</i>	<i>Pounds.</i>
The United States.....	18,112,707	237	7,728,583,349	1,492,699,143	299,006,818
North Atlantic Division.....	3,665,685	174	1,907,821,498	326,296,206	148,627,434
Maine.....	185,548	267	105,265,288	20,635,572	979,048
New Hampshire.....	118,751	289	62,489,215	11,419,881	221,080
Vermont.....	276,592	805	145,081,273	41,288,087	5,119,764
Massachusetts.....	199,452	71	112,644,623	9,568,272	270,171
Rhode Island.....	25,027	58	13,572,837	636,281	6,751
Connecticut.....	132,521	146	71,843,187	8,501,285	361,886
New York.....	1,537,921	212	790,048,027	115,606,980	130,419,747
New Jersey.....	167,799	89	82,650,255	7,219,882	124,377
Pennsylvania.....	1,022,074	162	524,226,793	111,394,966	11,124,610
South Atlantic Division.....	1,476,787	141	536,535,765	92,909,203	593,308
Delaware.....	33,645	182	13,181,918	2,599,838	15,104
Maryland.....	157,566	133	68,924,467	11,648,178	338,463
District of Columbia.....	1,809	6	1,115,399	3,478	.....
Virginia.....	301,906	163	114,582,203	20,076,851	88,697
West Virginia.....	217,538	227	89,531,735	16,975,220	115,108
North Carolina.....	246,755	130	95,974,824	16,913,802	28,883
South Carolina.....	136,333	102	48,614,803	8,150,437	1,081
Georgia.....	296,962	134	92,384,082	15,160,454	2,236
Florida.....	84,274	159	12,226,334	1,386,445	3,751
North Central Division.....	8,927,882	339	3,817,759,378	811,071,893	134,199,094
Ohio.....	868,832	209	449,902,069	87,668,620	19,323,528
Indiana.....	611,772	243	281,267,839	54,616,974	1,438,901
Illinois.....	1,064,491	221	484,099,820	86,600,162	9,381,904
Michigan.....	601,844	249	327,638,071	67,901,440	10,756,758
Wisconsin.....	1,032,811	499	488,620,914	106,573,740	79,384,298
Minnesota.....	789,683	451	321,141,331	82,363,315	3,575,642
Iowa.....	1,479,676	663	562,485,540	139,022,552	4,549,065
Missouri.....	814,578	262	281,573,955	47,027,916	1,642,891
North Dakota.....	131,119	411	51,512,880	9,642,003	296,280
South Dakota.....	280,024	697	103,705,225	23,573,077	567,642
Nebraska.....	638,856	505	202,976,111	46,244,839	578,030
Kansas.....	714,196	486	262,835,623	59,837,255	2,714,155
South Central Division.....	3,103,169	220	1,070,818,363	186,984,274	654,909
Kentucky.....	387,608	181	170,513,452	30,738,040	73,769
Tennessee.....	351,949	174	161,716,636	29,320,610	32,823
Alabama.....	302,129	165	106,743,453	19,139,321	46,374
Mississippi.....	316,217	204	105,057,410	18,929,761	28,572
Louisiana.....	197,264	143	45,164,688	4,918,229	135,104
Texas.....	924,899	303	281,683,798	48,214,206	194,423
Oklahoma.....	169,613	426	49,226,328	8,834,559	111,642
Indian Territory.....	119,362	304	30,614,480	5,105,715	1,227
Arkansas.....	334,128	255	120,098,118	21,753,833	30,985

^aTable XIII gives the aggregate of dairy cows and their products, by States and by groups of States, for the year 1900, and is the only table thus showing the aggregate dairy product of the country, because it includes all the cows, whether on farms or elsewhere, and the products of dairy establishments of every description, as well as of farms.

TABLE XIII.—*Dairying in the United States for 1900—Continued.*

States and Territories.	Dairy cows in United States.		Milk product reported plus estimated milk.	Total butter made.	Total cheese made.
	Total number.	Per 1,000 persons.			
			Gallons.	Pounds.	Pounds.
Western Division.....	935, 143	229	395, 050, 975	75, 312, 496	14, 932, 061
Montana	48, 317	199	17, 254, 689	2, 488, 310	30, 924
Wyoming	19, 923	215	5, 906, 199	918, 064	25, 327
Colorado	108, 697	201	42, 516, 066	6, 499, 121	1, 568, 441
New Mexico.....	18, 120	98	3, 648, 532	313, 008	68, 571
Arizona	18, 638	152	3, 875, 784	808, 394	407, 067
Utah	74, 284	268	29, 104, 667	5, 331, 336	2, 043, 430
Nevada	14, 178	335	4, 717, 771	1, 192, 925	174, 232
Idaho	54, 520	337	16, 353, 673	2, 952, 886	391, 332
Washington	119, 041	230	55, 791, 690	10, 570, 527	1, 633, 796
Oregon	132, 669	321	53, 438, 418	10, 082, 307	1, 662, 820
California	326, 756	220	162, 952, 466	34, 166, 133	6, 926, 131
Alaska	13	.....	4, 250	200	12
Hawaii	4, 028	26	594, 120	118, 871	

TABLE XIV.—*Butter, cheese, and condensed-milk factories, including all "creameries" and urban dairy establishments.*

[From the census of the United States for 1900, 1890, 1880, 1870.]

Totals for the United States.	1900. ^a	1890. ^a	1880.	1870.
Number of establishments reporting	9, 355	4, 712	3, 932	1, 313
Capital employed, aggregate.....dollars..	36, 508, 015	16, 624, 163	9, 604, 803	3, 690, 075
Plant, total value.....do.....	27, 301, 990	12, 089, 572	.....	.....
Land.....do.....	1, 848, 394	1, 114, 025	.....	.....
Buildings.....do.....	11, 556, 444	5, 738, 406	.....	.....
Machinery.....do.....	13, 897, 152	5, 237, 141	.....	.....
Live assets.....do.....	9, 206, 025	4, 534, 591	.....	.....
Expenses, total amount.....do.....	1, 590, 766	875, 182	.....	.....
Employees.....average number.....	6 15, 693	14, 921	7, 903	4, 607
Total wages paid.....dollars.....	7, 086, 112	5, 390, 705	1, 546, 495	706, 566
Materials used:				
Aggregate cost.....dollars.....	109, 151, 205	51, 364, 574	18, 363, 579	14, 089, 284
For butter—				
Gathered cream.....pounds.....	204, 740, 714	483, 630, 741	.....	.....
Milk.....do.....	8, 534, 911, 412	1, 893, 319, 242	.....	.....
Total cost.....dollars.....	75, 732, 159	29, 538, 827	4, 644, 214	.....
For cheese—				
Milk.....pounds.....	2, 749, 313, 613	2, 684, 550, 517	.....	.....
Total cost.....dollars.....	22, 007, 515	16, 953, 992	12, 692, 507	14, 089, 284
For condensed milk—				
Milk.....pounds.....	421, 378, 073	83, 617, 655	.....	.....
Sugar.....do.....	50, 873, 859	13, 372, 365	.....	.....
Total cost.....dollars.....	8, 907, 021	2, 792, 086	1, 026, 858	.....
Fuel, cost.....do.....	1, 712, 612	.....	.....	.....
Rented power and heat.....do.....	18, 667	.....	.....	.....
Mill supplies.....do.....	249, 938	.....	.....	.....
Freight.....do.....	523, 833	.....	.....	.....

^aIncludes urban establishments. See p. 28.^bIn addition to 7,104 proprietors and firm members.

TABLE XIV.—*Butter, cheese, and condensed-milk factories, etc.*—Continued.

Totals for the United States.	1900.	1890.	1880.	1870.
Products:				
Aggregate value.....dollars..	131,199,277	62,686,043	25,815,963	16,771,665
Butter, packed solid—				
Quantity.....pounds..	329,291,178			
Value.....dollars..	64,084,253			
Butter, prints or rolls—				
Quantity.....pounds..	91,662,838			
Value.....dollars..	20,241,163			
Butter, total made—				
Quantity.....pounds..	420,954,016	181,284,916	29,421,784	
Value.....dollars..	84,275,416	36,675,411	6,585,799	
Cream sold—				
Quantity.....gallons..	7,894,643			
Value.....dollars..	4,547,536			
Cheese, standard factory—				
Quantity.....pounds..	226,136,555	184,158,174		
Value.....dollars..	21,399,527	16,112,871		
Cheese, all other made—				
Quantity.....pounds..	56,497,938	53,876,891		
Value.....dollars..	5,170,953	3,690,060		
Cheese, total made—				
Quantity.....pounds..	282,634,493	238,035,065	215,845,361	109,485,229
Value.....dollars..	26,570,480	19,802,951	17,659,123	16,710,569
Condensed milk—				
Quantity.....pounds..	186,921,787	37,924,821	13,088,267	
Value.....dollars..	11,888,792	3,586,927	1,547,588	
Skim milk, value.....do....	2,555,468			
Dried casein.....do....	384,291	570,416	73,453	61,096
All other products.....do....	977,294			

NOTE.—In this table the figures in the column for 1870 relate to cheese factories, no other product being reported. The column for 1880 requires no explanation except that at this time butter factories or creameries had become numerous, although their product was but little more than one-third in value of the factory cheese produced.

For 1890 it should be noted that the figures are from the "number of establishments reporting." It is known that, in fact, there were many more creameries in operation in the country in 1889-90 than the number reported in the table. The aggregate products of factory-made butter and cheese thus shown must be considerably less than the actual output of existing factories. The census returns of total dairy products of the United States for 1889 must, therefore, be below the actual facts.

This table, although thus incomplete, shows the rapid growth of the cooperative or factory system of dairying. Farm cheese making has practically disappeared since the advent of cheese factories and creameries, and the proportion of factory-made butter is fast increasing, although the quantity of butter made on farms is increasing also.

In 1900 the number of creameries, etc., for New York was 1,928; this allows one for every 25 square miles in the State. These factories thus averaged but 5 miles apart, giving the longest average drive for their patrons as about 3 miles.

Wisconsin reported 2,019 creameries and cheese factories, or one for every 27 square miles; Vermont, one for every 36 square miles; Iowa, one for every 61 square miles, and Pennsylvania, one for every 60 square miles.

In connection with this table, attention is called to the Plates II, III, and IV.

TABLE XV.—*Number and value of milch cows in the United States, and of other farm animals, yearly, 1870 to 1903, inclusive, with a few earlier years.*

[From the Annual Reports of the Department of Agriculture.]

Year.	Milch cows.		Oxen and other cattle.		Horses.		Total value of farm animals.
Jan. 1—	Number.	Value.	Number.	Value.	Number.	Value.	
1840....	4,837,043	\$72,555,000	10,171,586	.....	4,335,669	.....	.....
1850....	6,385,094	127,840,890	11,393,813	.....	4,336,719	.....	\$544,180,516
1860....	8,585,735	264,643,375	17,034,284	.....	6,249,174	.....	1,089,329,915
1870....	10,095,600	394,940,745	15,388,500	\$346,926,440	8,248,800	\$671,319,461	1,822,327,377
1871....	10,023,000	374,179,093	16,212,200	369,940,056	8,702,000	683,257,587	1,810,142,711
1872....	10,303,500	329,408,983	16,389,800	321,562,693	8,990,900	659,707,916	1,659,211,933
1873....	10,575,900	314,358,931	16,413,800	329,298,755	9,222,470	684,463,967	1,684,431,693
1874....	10,705,300	299,609,309	16,218,100	310,649,803	9,333,800	666,927,406	1,619,944,472
1875....	10,906,800	311,089,824	16,313,400	304,858,859	9,504,200	646,370,989	1,618,012,221
1876....	11,085,400	320,346,728	16,785,300	319,623,509	9,735,300	632,446,985	1,647,719,138
1877....	11,260,800	307,743,211	17,966,100	307,105,386	10,155,400	610,206,631	1,576,506,063
1878....	11,300,100	298,499,866	19,223,300	329,541,708	10,329,700	600,813,681	1,574,623,783
1879....	11,826,400	256,953,928	21,408,100	329,543,327	10,938,700	573,254,808	1,445,423,062
1880....	12,027,000	279,899,420	21,231,000	341,761,154	11,201,800	613,296,611	1,576,917,536
1881....	12,368,653	296,277,060	20,938,710	362,861,509	11,429,626	667,964,327	1,721,796,252
1882....	12,611,632	326,489,310	23,280,238	463,069,501	10,521,554	615,824,914	1,906,468,252
1883....	13,125,685	396,575,405	28,046,077	611,549,109	10,838,110	765,041,308	2,338,215,768
1884....	13,501,206	423,486,649	29,046,101	683,229,054	11,169,683	833,734,400	2,467,868,924
1885....	13,904,722	412,903,093	29,866,573	694,382,913	11,564,572	852,282,947	2,456,428,383
1886....	14,235,388	389,985,523	31,275,242	661,956,274	12,077,657	860,823,208	2,365,159,862
1887....	14,522,063	378,789,589	33,511,750	663,137,926	12,496,744	901,685,755	2,400,586,938
1888....	14,856,414	366,252,173	34,378,363	611,750,520	13,172,936	946,096,154	2,409,043,418
1889....	15,298,625	366,226,376	35,082,417	597,238,812	13,663,294	962,194,827	2,507,050,068
1890....	15,952,883	353,152,133	36,849,024	560,625,137	14,213,837	978,516,562	2,418,766,028
1891....	16,019,591	346,397,900	36,875,648	544,127,908	14,066,760	941,823,222	2,329,787,770
1892....	16,416,351	351,378,132	37,651,239	570,749,155	15,498,140	1,007,593,636	2,461,755,698
1893....	16,424,087	357,299,785	35,954,196	547,882,204	16,206,802	992,225,185	2,483,506,681
1894....	16,487,400	358,998,661	36,608,168	536,789,747	16,081,139	769,224,799	2,170,816,754
1895....	16,504,629	362,601,729	34,364,216	482,999,129	15,893,318	576,730,580	1,819,446,306
1896....	16,137,586	363,955,545	32,085,409	508,928,416	15,124,057	500,140,186	1,727,926,084
1897....	15,941,727	369,239,993	30,508,408	507,929,421	14,364,667	452,649,396	1,655,414,612
1898....	15,840,886	434,813,826	29,264,197	612,296,634	13,960,911	478,362,407	1,891,577,471
1899....	15,990,115	474,233,925	27,994,225	637,931,135	13,665,307	511,074,813	1,997,010,407
1900....	16,292,360	514,812,106	27,610,054	689,486,260	13,537,524	603,969,442	2,042,650,813
1901....	16,833,657	505,093,077	45,500,213	906,644,003	16,744,723	885,200,168	3,011,254,076
1902....	16,696,802	488,130,324	44,727,797	839,126,073	16,531,224	968,935,178	2,969,170,150
1903....	17,105,227	516,711,914	44,659,206	824,054,902	16,567,373	1,030,705,959	3,102,515,540

a Exclusive of hogs.

NOTE.—Some of the figures above agree exactly with those of the census for the corresponding year. In other cases, for census years, the numbers of animals as reported by the Department differ somewhat from those of the census.

These numbers are understood to represent only animals on farms.

The values from 1870 to 1878 were currency values; those for 1880 and later were on gold basis.

TABLE XVI.—*Farm statistics by States.*

[From the Twelfth United States Census, 1900.]

States and Territories.	Popula- tion.	Persons "in agri- culture."	Farms.	Average size of farms.	Dairy cows on farms and ranges.	All other neat cattle over 1 year.
		Number.	Number.	Acres.	Number.	Number.
The United States	76,303,387	10,438,219	5,739,657	147	17,139,674	35,349,563
North Atlantic Division	21,046,695	1,074,412	677,506	96	3,496,266	1,585,350
Maine	694,466	76,923	59,299	106	173,592	103,461
New Hampshire	411,588	38,782	29,324	123	115,036	71,332
Vermont	343,641	49,820	33,104	143	270,194	130,162
Massachusetts	2,805,346	66,551	37,715	89	184,562	57,761
Rhode Island	428,556	10,967	5,498	83	23,660	7,036
Connecticut	908,420	44,796	26,948	86	126,434	53,324
New York	7,268,894	375,990	226,720	100	1,501,608	587,641
New Jersey	1,883,669	68,881	34,650	82	157,407	42,892
Pennsylvania	6,302,115	341,712	224,248	86	943,773	531,751
South Atlantic Division	10,443,480	2,032,569	962,225	108	1,383,319	2,106,982
Delaware	184,735	19,002	9,687	110	32,591	12,226
Maryland	1,188,044	95,554	46,012	112	147,294	89,897
District of Columbia	273,718	1,488	269	32	1,251	142
Virginia	1,854,184	300,268	167,886	119	281,876	381,583
West Virginia	958,800	151,722	92,874	115	205,601	300,074
North Carolina	1,893,810	459,306	224,637	101	233,178	248,654
South Carolina	1,340,316	393,693	155,355	90	126,684	128,480
Georgia	2,216,331	522,848	224,691	118	276,024	411,888
Florida	528,542	88,688	40,814	107	78,830	534,038
North Central Division	26,333,004	3,508,808	2,196,567	144	8,490,284	14,819,176
Ohio	4,157,545	414,562	276,719	88	818,239	740,490
Indiana	2,516,462	342,733	221,897	97	574,276	682,093
Illinois	4,821,550	462,781	264,151	124	1,007,664	1,373,024
Michigan	2,420,982	312,462	203,261	86	563,905	437,021
Wisconsin	2,069,042	270,007	169,795	117	998,397	692,365
Minnesota	1,751,394	258,944	154,659	170	753,632	551,699
Iowa	2,231,853	371,604	228,622	151	1,423,648	2,653,703
Missouri	3,106,665	463,293	284,886	119	765,386	1,579,886
North Dakota	319,146	71,626	45,332	343	125,503	375,511
South Dakota	401,570	82,857	52,622	362	270,634	933,025
Nebraska	1,066,300	186,587	121,525	246	512,544	1,909,199
Kansas	1,470,495	271,252	173,098	241	676,456	2,891,160
South Central Division	14,080,047	3,300,817	1,658,166	155	2,899,236	10,924,148
Kentucky	2,147,174	408,185	234,667	94	364,025	468,721
Tennessee	2,020,616	413,406	224,623	91	321,676	354,507
Alabama	1,828,697	515,737	223,220	93	279,263	307,074
Mississippi	1,551,270	490,582	220,803	83	299,318	335,437
Louisiana	1,381,625	295,445	115,969	95	184,815	315,655
Texas	3,048,710	614,634	352,190	357	861,023	6,418,912
Oklahoma	398,331	94,931	62,495	252	165,852	1,243,775
Indian Territory	392,060	92,418	45,505	160	110,687	1,152,582
Arkansas	1,311,564	345,479	178,694	93	312,577	327,485
Western Division	4,091,349	465,159	242,908	386	866,528	5,832,539
Montana	243,329	28,693	13,370	886	45,036	735,818
Wyoming	92,531	13,407	6,096	1,333	18,272	542,242
Colorado	539,700	44,904	24,700	384	100,116	1,064,048
New Mexico	195,310	27,214	12,311	417	16,775	786,322

TABLE XVI.—*Farm statistics by States—Continued.*

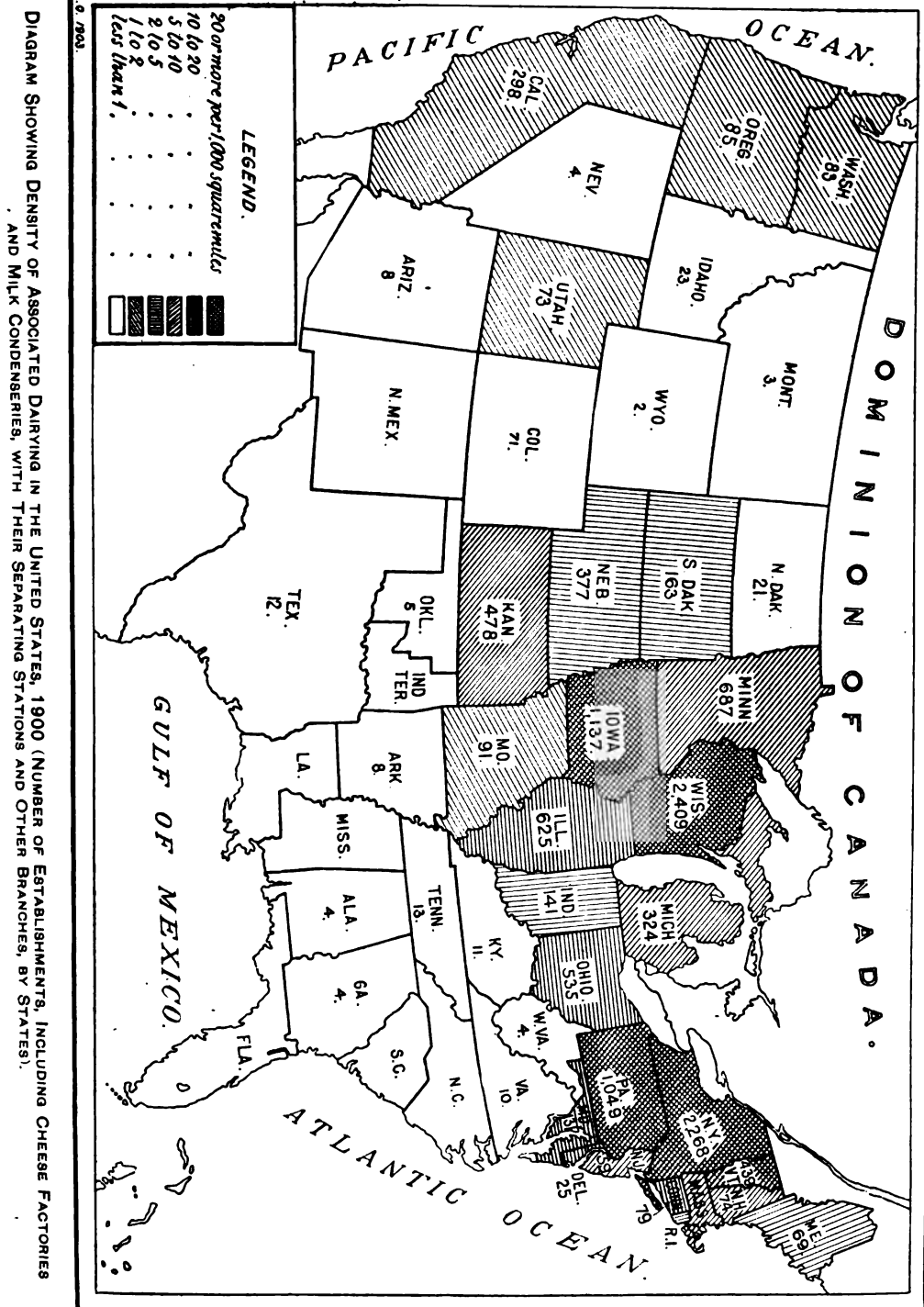
States and Territories.	Popula- tion.	Persons "in agri- culture."	Farms.	Average size of farms.	Dairy cows on farms and ranges.	All other neat cattle over 1 year.
Western Division—Continued.		Number.	Number.	Acres.	Number.	Number.
Arizona	122,931	16,174	5,809	333	17,965	569,489
Utah	276,749	29,414	19,387	212	65,905	198,845
Nevada	42,335	5,890	2,184	1,175	13,606	290,525
Idaho	161,772	27,489	17,471	183	51,929	225,207
Washington	518,103	61,113	33,202	256	107,232	182,561
Oregon	413,536	58,490	35,887	281	122,447	409,533
California	1,485,053	152,371	72,542	397	307,245	807,949
Alaska	68,592	367	12	13	13	5
Hawaii	154,001	53,076	2,273	1,148	4,028	81,363

TABLE XVII.—*Population and number of cows per square mile of land surface in each State and Territory in 1900.*

States and Territories.	Popula- tion.	Cows.	States and Territories.	Popula- tion.	Cows.
United States	25.62	6.10	Nebraska	13.88	7.14
Alabama	35.48	5.86	Nevada	.39	.13
Arizona	1.09	.16	New Hampshire	45.71	13.19
Arkansas	24.73	6.30	New Jersey	250.32	22.30
California	9.52	2.09	New Mexico	1.59	.15
Colorado	5.21	1.05	New York	152.64	32.30
Connecticut	187.50	27.35	North Carolina	38.98	5.08
Delaware	94.25	17.17	North Dakota	4.55	1.87
Florida	9.74	1.55	Ohio	102.00	21.31
Georgia	37.58	5.03	Oklahoma	10.26	4.37
Idaho	1.92	.65	Oregon	4.37	1.40
Illinois	86.10	19.01	Pennsylvania	140.09	22.72
Indiana	70.08	17.04	Rhode Island	406.99	23.77
Iowa	40.23	26.67	South Carolina	44.43	4.52
Kansas	18.00	8.74	South Dakota	5.23	3.64
Kentucky	53.68	9.69	Tennessee	48.40	8.43
Louisiana	30.42	4.34	Texas	11.62	3.53
Maine	23.23	6.21	Utah	3.37	.90
Maryland	120.49	15.98	Vermont	37.62	30.28
Massachusetts	348.92	24.81	Virginia	46.21	7.52
Michigan	42.16	10.48	Washington	7.75	1.78
Minnesota	22.11	9.97	West Virginia	38.90	8.83
Mississippi	33.48	6.82	Wisconsin	38.00	18.97
Missouri	45.20	11.85	Wyoming	.95	.20
Montana	1.67	.33			

a Not including Hawaii and Alaska.

NOTE.—Plate I which is seen opposite page 48 serves to illustrate Table XVII.



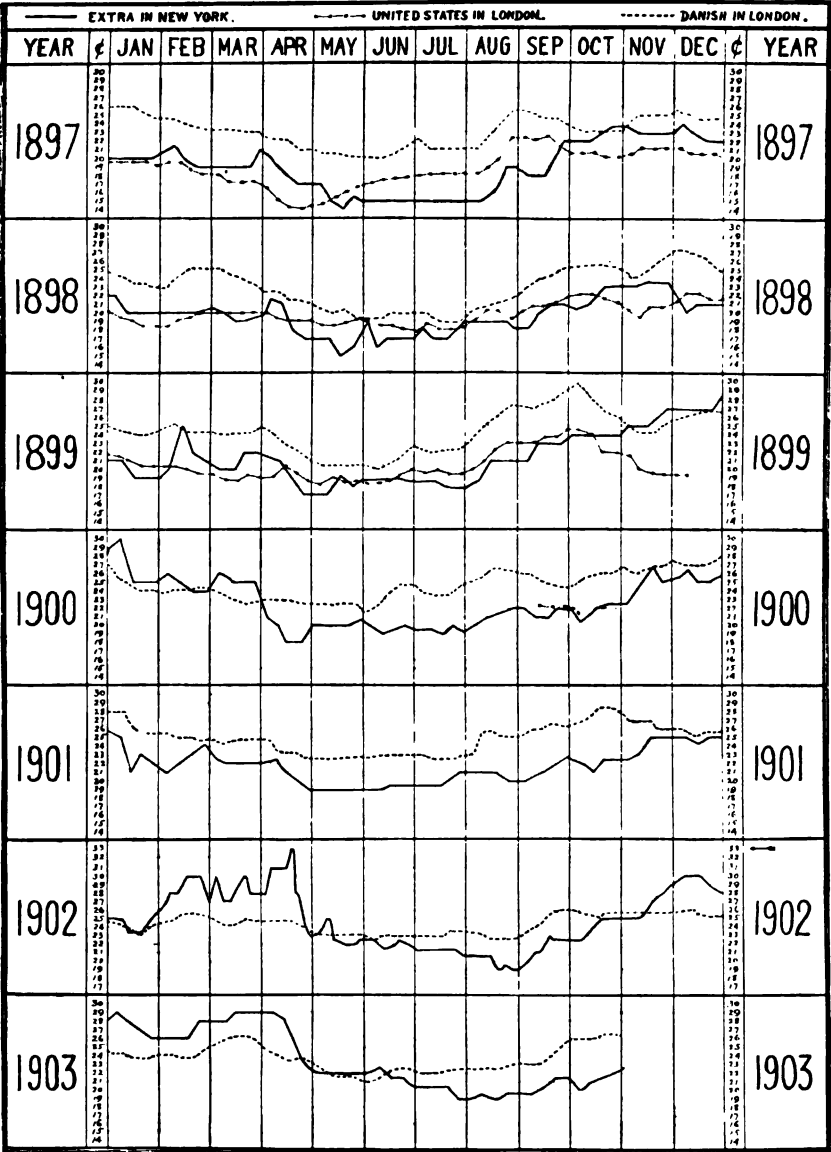


DIAGRAM SHOWING BUTTER QUOTATIONS IN NEW YORK AND LONDON.

TABLE XVIII.—Pounds of cheese and butter produced per square mile of land surface in each State and Territory in 1900.

States and Territories.	Cheese.	Butter.	States and Territories.	Cheese.	Butter.
United States.....	100.67	502.55	Nebraska.....	7.52	601.83
Alabama.....	0.90	871.35	Nevada.....	1.59	10.87
Arizona.....	8.60	7.11	New Hampshire.....	24.55	1,268.17
Arkansas.....	.58	410.10	New Jersey.....	16.58	959.45
California.....	44.40	219.04	New Mexico.....	.56	2.56
Colorado.....	15.13	62.71	New York.....	2,738.76	2,427.70
Connecticut.....	74.69	1,754.65	North Carolina.....	.59	848.16
Delaware.....	7.71	1,326.45	North Dakota.....	4.22	187.86
Florida.....	.07	25.56	Ohio.....	474.06	2,150.85
Georgia.....	.04	257.04	Oklahoma.....	2.88	227.52
Idaho.....	4.64	35.03	Oregon.....	17.56	106.63
Illinois.....	167.53	1,546.43	Pennsylvania.....	247.30	2,476.27
Indiana.....	40.07	1,520.94	Rhode Island.....	6.41	604.26
Iowa.....	82.00	2,506.04	South Carolina.....	.04	270.15
Kansas.....	33.22	732.40	South Dakota.....	7.26	306.74
Kentucky.....	1.84	768.45	Tennessee.....	.79	702.29
Louisiana.....	2.97	106.28	Texas.....	.74	183.93
Maine.....	32.75	690.27	Utah.....	24.86	64.87
Maryland.....	34.33	1,180.85	Vermont.....	560.46	4,519.77
Massachusetts.....	33.60	1,193.19	Virginia.....	2.22	500.85
Michigan.....	187.30	1,182.33	Washington.....	24.43	156.06
Minnesota.....	45.14	1,039.88	West Virginia.....	4.67	688.79
Mississippi.....	.62	408.50	Wisconsin.....	1,457.93	1,957.28
Missouri.....	23.90	684.19	Wyoming.....	.26	9.41
Montana.....	.21	17.12			

TABLE XIX.—Rank of each State and Territory in 1900 in regard to various matters—Continued.

[United States Census.]

States and Territories.	Land area.	Population.	Persons in agri- culture.	Number of cows.	Milk produced.	Butter produced.	Cheese produced.	Persons per square mile.	Cows per square mile.	Butter per square mile.	Cheese per square mile.
Alabama.....	26	18	3	19	21	22	37	25	28	28	37
Arizona.....	5	46	45	46	48	46	21	46	46	47	31
Arkansas.....	25	25	14	16	18	19	39	28	26	26	42
California.....	2	21	24	17	15	15	7	36	36	34	11
Colorado.....	7	31	37	38	38	37	15	39	41	41	23
Connecticut.....	46	29	38	34	29	34	23	4	3	7	9
Delaware.....	47	44	44	43	43	41	44	9	12	10	24
Florida.....	24	32	28	39	44	43	46	35	31	43	46
Georgia.....	19	11	2	21	26	26	47	24	30	32	47
Idaho.....	10	45	42	41	41	40	22	43	43	42	29
Illinois.....	21	3	6	3	5	6	6	10	10	8	7
Indiana.....	37	8	15	11	11	10	16	11	13	9	12
Iowa.....	22	10	13	2	2	1	9	19	4	2	8
Kansas.....	12	22	20	10	12	9	11	31	21	18	15
Kentucky.....	35	12	10	14	14	16	35	12	19	17	35
Louisiana.....	30	23	19	27	37	39	30	27	33	38	32

TABLE XIX.—*Rank of each State and Territory in 1900 in regard to various matters—Continued.*

States and Territories.	Land area.	Population.	Persons in agri- culture.	Number of cows.	Milk produced.	Butter produced.	Cheese produced.	Persons per square mile.	Cows per square mile.	Butter per square mile.	Cheese per square mile.
Maine	39	30	30	28	22	20	18	29	27	20	16
Maryland	41	26	26	31	30	27	24	7	14	14	13
Massachusetts	44	7	33	26	20	32	26	2	5	12	14
Michigan	20	9	17	12	7	8	5	18	17	13	6
Minnesota	13	19	22	9	8	7	10	30	18	15	10
Mississippi	29	20	4	18	23	23	42	26	25	27	40
Missouri	17	5	5	8	10	12	17	16	16	22	20
Montana	3	42	41	42	40	42	40	44	44	44	45
Nebraska	15	27	23	13	13	13	19	32	24	24	25
Nevada	6	48	48	48	46	44	29	48	48	45	36
New Hampshire	43	36	39	37	31	28	27	15	15	11	18
New Jersey	45	16	32	30	28	36	31	8	8	16	22
New Mexico	4	43	43	47	47	48	36	45	47	48	43
New York	28	1	12	1	1	2	1	5	1	4	1
North Carolina	27	15	7	24	25	25	41	20	29	29	41
North Dakota	16	40	31	35	34	31	25	40	37	37	30
Ohio	33	4	8	7	6	5	3	8	9	5	4
Oklahoma	36	34	27	29	35	33	33	34	32	33	33
Oregon	9	35	35	33	33	30	13	41	40	39	21
Pennsylvania	31	2	16	5	3	3	4	6	7	3	5
Rhode Island	48	34	47	44	42	47	45	1	6	23	27
South Carolina	34	24	11	32	36	35	48	17	31	31	48
South Dakota	14	37	29	22	24	18	20	38	34	30	26
Tennessee	32	14	9	15	16	17	38	13	22	19	38
Texas	1	6	1	6	9	11	28	33	35	35	39
Utah	11	41	40	40	39	38	12	42	42	40	17
Vermont	42	39	36	23	17	14	8	23	2	1	3
Virginia	34	17	18	20	19	21	34	14	23	25	34
Washington	18	33	34	36	32	29	14	37	38	36	19
West Virginia	40	28	25	25	27	24	32	21	20	21	28
Wisconsin	23	13	21	4	4	4	2	22	11	6	2
Wyoming	8	47	46	45	45	45	43	47	45	46	44

NOTE.—The above table is based on data in Tables XIII, XVI, XVII, and XVIII. The first three columns show the rank of each State and Territory in size, total population, and agricultural population. The next two columns show their rank in the total number of cows and total milk production. It will be seen that in almost every case where dairying is extensively practiced a State ranks higher in total milk production than number of cows, showing the superior class of stock. The sixth and seventh columns show the rank in the total production of butter and cheese. The last four columns show intensity, and are more interesting in some respects than any of the others. One's opinion of the condition of dairying in any State is often formed by the total production, which depends largely on the size of the State. But some of the small States may have a much higher development of their dairy industry and produce more per square mile than large ones that produce a large total, as is shown in Table XVIII. The ranks of the States and Territories in regard to production per square mile are given in the last two columns.

TABLE XX.—Average value of a cow in the United States for the years stated.

[United States Census and Department of Agriculture.]

Year.	Value.	Year.	Value.
January 1—		January 1—	
1850	\$20.02	1897	\$23.16
1860	30.82	1898	27.45
1870	^a 32.74	1899	29.66
1880	23.27	1900	31.60
1885	29.70	1901 ^b	29.68
1890	22.14	1902	29.23
1895	21.97	1903	30.21
1896	22.55		

^aOn gold basis.^bCensus June 1, 1900.

TABLE XXI.—Registered or pedigreed cattle of selected breeds in the United States and their values (estimates furnished by the secretaries of the respective breeders' associations).

[From Report for 1885, United States Department of Agriculture.]

Breed.	Number registered.	Number living.	Average value.	Total value.
Aberdeen Angus		3,500	\$300	\$1,050,000
Ayrshire	12,867	6,483	100	643,300
Devon	10,187	8,000	81	648,000
Guernsey	4,947	3,100	149	461,000
Hereford		14,000	300	4,200,000
Holstein-Friesian	21,138	20,081	200	4,016,200
Jersey	51,000			

[For the year 1885, as reported to the Dairy Division.]

Ayrshire	18,750	9,375	\$100	\$937,500
Brown-Swiss	1,930	1,200	150	180,000
Devon	17,007	14,500	81	1,174,500
Dutch-Belted	971	720	200	144,000
Guernsey	12,547	8,500	165	1,402,500
Holstein-Friesian	90,325	70,000	100	7,000,000
Jersey	150,000	100,000	100	10,000,000
"Maine State" Jersey	3,927	2,800	55	154,000
Red Polled	4,408	3,000	80	240,000

[For the year 1903, as reported to the Dairy Division.]

Ayrshire	25,541	8,500	\$100	\$850,000
Brown-Swiss	3,258	1,800	75	135,000
Devon	20,717	9,000	75	675,000
Dutch-Belted	1,524	600	200	120,000
Guernsey	24,337	15,000	140	210,000
Holstein-Friesian	115,009	75,000	130	9,750,000
Jersey	237,680	125,000	100	12,500,000
Polled Durham	6,077	5,000	80	400,000
Polled Jersey	286	250	100	25,000
Red Polled	30,330	25,000	150	3,750,000
Shorthorn ^a	564,839	420,000	170	71,400,000

^aNumbers and average value refer chiefly to beef stock.

TABLE XXII.—*Growth of the factory system in the United States—States, years, and number of factories, from various sources.*

	Year.	Num-ber.		Year.	Num-ber.		Year.	Num-ber.
United States ...	1850	8	Iowa	1866	1	Ohio	1860	2
	1860	10		1870	14		1862	1
	1861	56		1874	45		1874	108
	1864	402		1888	466		1880	452
	1870	1,313		1894	870		1890	361
	1900	9,355		1900	907		1900	484
Connecticut	1851	1	Maine	1869	1	Vermont.....	1870	28
	1870	7		1874	40		1874	32
	1880	16		1880	41		1880	85
	1890	50		1890	42		1890	124
	1900	72		1894	58		1894	250
Illinois.....	1862	1		1900	61		1900	255
	1874	45	New York	1851	1	Wisconsin	1841	1
	1875	200		1861	3		1864	2
	1890	266		1864	269		1865	30
	1894	530		1865	484		1872	150
	1900	534		1874	1,018		1874	175
				1900	1,928		1900	2,019

The first cheese factory and first creamery were started, respectively, in New York in 1861 and 1864; in Illinois, 1862 and 1870; in Iowa, 1866 and 1871.

DAIRY STATISTICS LATER THAN 1900 RELATING TO SEVERAL STATES.

CALIFORNIA.

[From the Fourth Report of the State Dairy Bureau.]

There were (October 1, 1902) 4,320 farmers and dairymen owning herds of 10 or more cows who were engaged in the production of butter, cheese, or milk. In the same year there were in the State 292 creameries, 341 cheese factories, and 5 condensed-milk factories. The amount of creamery butter made in 1901 was 19,017,512 pounds, and, in 1902, 21,593,021 pounds. The annual value of the dairy output was as follows:

Output of dairy products in 1900-1901.

29,730,889 pounds of butter	\$6, 838, 103
5,679,566 pounds of cheese	567, 956
100,140 cases of condensed milk and cream	380, 532
Milk and cream consumed	6, 236, 557
Calves from dairy cows	1, 422, 603
Hogs produced at dairies and creameries	1, 641, 459
	17, 087, 210

Output of dairy products in 1901-02.

31,424,135 pounds of butter	\$7, 541, 792
6,503,441 pounds of cheese	702, 371
146,680 cases of condensed milk and cream	564, 758
Milk and cream consumed	6, 236, 555
Calves from dairy cows	1, 568, 040
Skim milk, etc., made into pork	1, 710, 040
	18, 323, 556

COLORADO.

[From the Annual Report, November, 1902, of T. L. Munson, State Dairy Commissioner.]

The number of creameries, cheese factories, and skimming stations was 86 in 1902. The total number of dairy cows was 81,546, of which 26,160 supplied market milk, 20,000 supplied the creameries, and 2,500 supplied the cheese factories. The milk from 12,000 was used in making ranch butter, and 500 supplied milk to condensed-milk factories; the remainder were dry.

BUREAU OF ANIMAL INDUSTRY.

Value of dairy products, 1902.

6,716,000 pounds creamery butter, at 25 cents	\$1, 679, 000
2,336,000 pounds of ranch butter, at 20 cents	467, 200
1,788,500 pounds cheese, at 14 cents	250, 390
518,400 cans condensed milk, at 8½ cents (average)	43, 198
5,840,000 quarts cream consumed and used in ice cream manufacture, at 16 cents	934, 400
89,936,000 quarts pure milk consumed, at 3¼ cents per quart, wholesale	2, 922, 920
Skim milk and buttermilk, at one-half cent per quart, whole- sale	332, 880
All dairy products	6, 629, 988

INDIANA.

[From township assessors' returns furnished by B. F. Johnson, Chief Indiana Bureau of Statistics, for the year 1902.]

Number of milch cows	543, 648
Butter made on farms, pounds	34, 755, 464
Cheese made on farms, pounds	6, 762, 731
Milk produced on or sold from farms, gallons	145, 602, 678
Creameries	58
Cheese factories	2

IOWA.

[From the 1901 Report of the Iowa State Dairy Commissioner.]

	1899.	1900.	1901.
Number of patrons of creameries	90, 364	91, 417	89, 376
Average number of patrons per creamery	116	113	114
Total number of cows contributing to creameries	625, 512	631, 829	627, 984
Average number of cows per creamery	804	781	801
Average number of cows per patron	7	7	7
Number of creameries that use Mann's acid test		85	139
Number of creameries that use Farrington's test		22	35
Number of creameries that pasteurize the skimmed milk	78	205	270

[From the 1902 Report of the Iowa State Dairy Commissioner, H. R. Wright.]

Number of cows per 1,000 persons	637
Number of cows per square mile	25
Number of milch cows in the State	1, 423, 348
Value of cows	\$34, 540, 890
Number of creameries	920
Number of creamery patrons	81, 532
Number of cheese factories	52
Butter made in creameries and factories, pounds	77, 885, 696
Cheese made in creameries and factories, pounds	3, 511, 798
Average price of Iowa butter at New York, cents	24. 16
Number of farm separators	8, 323

The number of farm separators reported in 1898 was 904; in 1899, 1,762; in 1900, 3,332; in 1901, 5,231; in 1902, 8,323—showing an increase of nearly 60 per cent, while in 1903 there were 16,800, an increase of over 100 per cent. The 13 renovated-butter factories manufactured 4,530,388 pounds of renovated butter. Of the "packing

stock" for this product, 1,469,281 pounds was purchased in Iowa and 3,061,107 pounds was purchased elsewhere. Almost 1,000,000 pounds of this renovated butter was consumed within the State.

KANSAS.

[Returns from the State Board of Agriculture Report for 1902.]

Number of milch cows.....	791, 844
Value of milch cows.....	\$23, 755, 320
Butter made on farms, pounds	27, 056, 683
Butter made in creameries and factories, pounds.....	17, 294, 146
Value of total butter made	\$7, 517, 332
Cheese made on farms.....	147, 179
Cheese made in creameries and factories, pounds	2, 878, 476
Value of total cheese made.....	\$302, 565
Value of milk sold otherwise than for butter and cheese...	\$725, 380

MINNESOTA.

[Statistics furnished by W. W. P. McConnell, State Dairy Commissioner.]

For 1902.

Milk received at creameries and cheese factories, pounds..	1, 151, 684, 174
Butter made, pounds	63, 726, 808
Amount paid to creameries for butter sold	\$13, 909, 898
Cheese made, pounds.....	3, 291, 171
Amount paid to cheese factories for cheese sold.....	\$292, 286
Total for butter and cheese (factory product)	\$14, 202, 183

For 1903.

January 1, 1903, there were in operation 681 creameries (526 cooperative and 155 independent or individual), 53 skimming stations, and 141 cheese factories. The number of cows supplying milk to creameries and cheese factories was 382,356.

Report of Cheddar cheese industry for 1901.

Milk received by factories, pounds	33, 896, 724
Cheese made, pounds.....	3, 291, 171
Milk for 1 pound of cheese, pounds.....	10. 3
Price per 100 pounds of milk paid patrons, cents	75. 6
Cheese shipped outside of State, pounds	187, 803
Cheese sold within the State, pounds	3, 103, 368
Total amount of money paid patrons for milk	\$255, 581
Total number of Cheddar cheese factories	54

The statistics below combine the make of Swiss, Brick, and Limburger cheese made in the State. The report shows a wonderful increase over two years ago:

Report of sweet-curd industry for 1901.

Milk received by factories, pounds	5, 097, 824
Cheese made, pounds.....	408, 429
Milk for 1 pound of cheese, pounds.....	10. 5
Price paid patrons for 100 pounds milk, cents	71
Cheese sold outside State, pounds	9, 281
Cheese sold within State, pounds.....	399, 148
Total amount of money paid patrons for milk	\$36, 704
Total number of sweet-curd cheese factories.....	14

NEW YORK.

[From Bulletin No. 6, State Department of Agriculture, and letter from Geo. L. Flanders, assistant commissioner, July 15, 1902.]

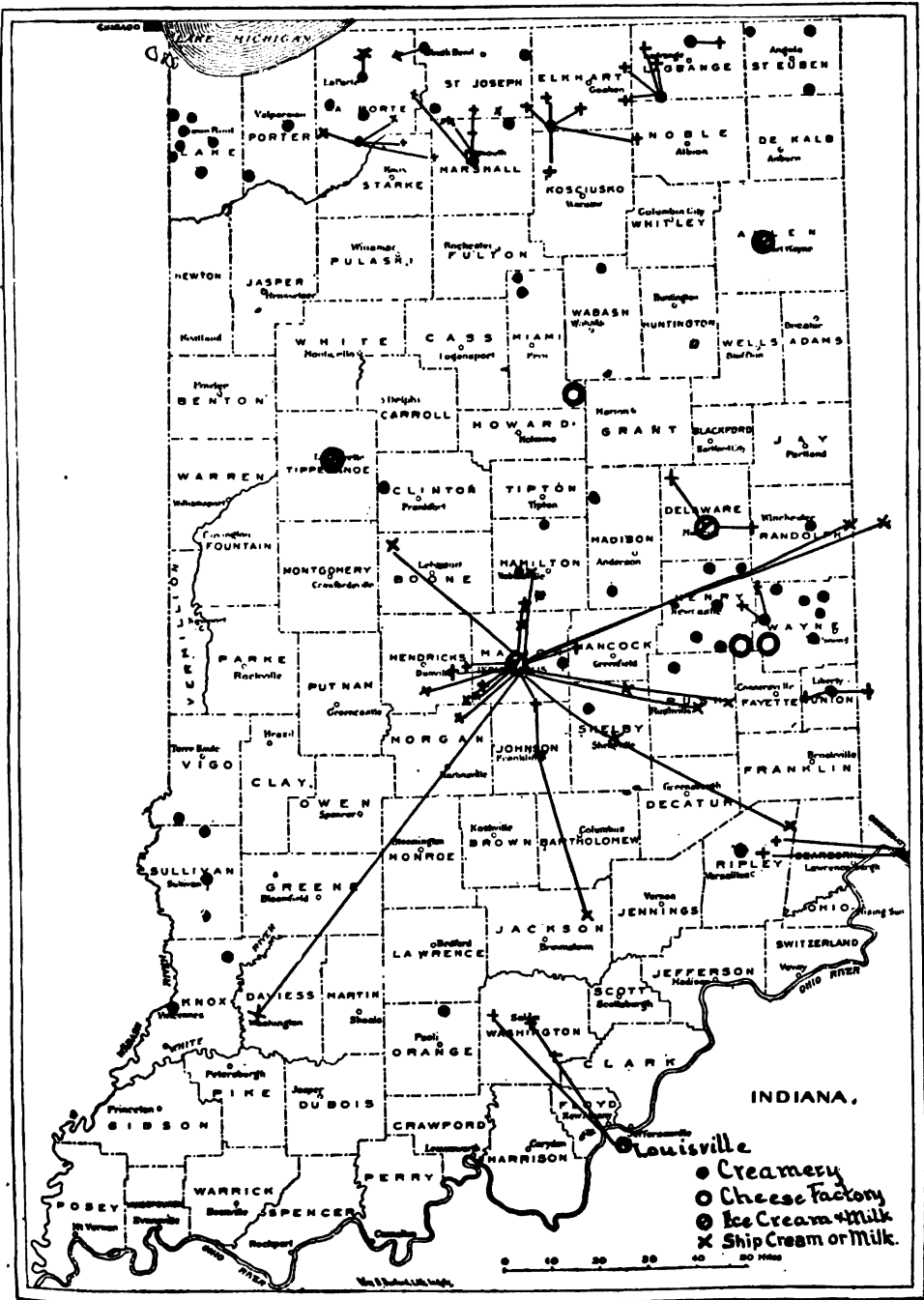
New York has 61 counties: dairy establishments are operated in 52 of them. Statistics are as follows for the year 1902:

Establishments.	Factories.	Butter.	Cheese.
	Number.	Pounds.	Pounds.
Butter factories.....	448	40,060,478	
Cheese factories.....	1,010		90,006,402
Factories making both butter and cheese.....	193	5,117,251	29,282,911
Milk stations.....	539	4,646,561	4,056,523
Condenseries.....	18	95,504	639,280
Total.....	2,208	49,919,794	123,987,116

Increased number of pounds of butter over 1900.....	10,736,483
Decreased number of pounds of cheese as compared with 1900.....	2,671,156
Pounds of dried casein made in 1902.....	6,394,711
Received at milk stations and condenseries, 1902 (milk in quarts).....	594,815,567
Milk sold, quarts.....	383,498,501
Cream sold, quarts.....	15,152,363
Condensed milk made, quarts.....	35,344,450

The production of cheese is divided as to variety as follows:

Kind.	1900.	1902.
Full cream.....	105,824,927	99,074,630
Skim.....	9,222,638	12,128,367
Pineapple.....	24,480	157,960
Limburger.....	2,897,434	4,531,932
Domestic Swiss.....	588,622	879,533
Kosher.....	10,530	438,687
D'Isigny.....	821,747	1,292,992
Neufchâtel.....	1,171,305	1,605,042
Fromage de Brie.....	141,890	510,312
Square cream.....	457,685	1,446,229
Imitation English Cheddar.....	4,869,928	816,150
Wiener.....		4,000
Sage.....	24,319	680
Munster.....	391,667	2
Other kinds.....	40,000	



MAP OF INDIANA, WITH LOCATION OF CREAMERIES, ETC.

BULLETIN NO.







MAP OF OHIO WITH LOCATION OF CREAMERIES, ETC.

NORTH DAKOTA.

[From annual report of Commissioner of Agriculture and Labor, E. E. Kaufman, assistant dairy and food commissioner.]

Number of cattle, 1902	463, 751
Value of all cattle	\$6, 287, 885
Number of cows used for dairying	73, 571
Number of cheese factories, October, 1902	4
Number of creameries	37
Number of skimming stations	5
Number of creamery patrons	1, 750
Number of milch cows owned by patrons	13, 921
Butter made at creameries, 1901, pounds	1, 796, 576
Butter made on farms, 1901, pounds	5, 794, 538
Cheese made on farms, 1901, pounds	35, 653
Total value of milk sold	\$293, 912
Number of creameries, 1903	56
Number of skimming stations, 1903	5

The first creamery was started in 1895. Nearly 1,000 separators were sold to farmers in this State in 1902, so that there are fully 2,000 of these machines now in use. In addition to the butter and cheese manufactured within the State, many thousands of pounds of cream were shipped to Minneapolis, Minn., and Aberdeen, S. Dak.

OHIO.

[Statistics compiled by J. W. Decker, Columbus, Ohio.]

There are in Ohio (1902) about 800,000 milch cows, valued at \$25,000,000. The farms on which they are kept are cared for by an army of 80,000 men. The creameries, cheese factories, etc., are as follows:

	Coopera- tive.	Private.	Stock com- pany.	Not re- ported.	Total.	Number of coun- ties dis- tributed.
Butter factories	53	87	6	2	148	54
Skimming stations	18	56	2	1	77	30
American cheese factories	5	107		2	114	18
Swiss cheese factories	61	31			92	8
Total of classification	137	281	8	5	431	65
Milk shipping stations					22	10

OREGON.

[J. W. Bailey, State dairy commissioner.]

Number of cheese factories, 1902	175
Number of creameries, 1902	141
Cheese made in factories, estimated, pounds	2, 235, 000
Butter made in creameries, estimated, pounds	4, 000, 000
Dairy butter marketed in the State, estimated, pounds	3, 500, 000
Cream and milk sales, estimated	\$1, 800, 000
Value of dairy products (not including those consumed on farms)	\$3, 597, 000

The output of butter and cheese in the past two years has increased, according to the best information obtainable, about 50 per cent. There has also been a rapid increase in the number of creameries.

WASHINGTON.

[E. A. McDonald, State Dairy Commissioner.]

	1901.	1902.
Number of creameries	247	345
Creamery butter.....pounds..	4,886,828	5,883,251
Number of cheese factories	37	41
Output from cheese factories.....pounds..	1,106,933	1,128,735

VERMONT.

[From the Thirty-third Report of the Vermont Dairymen's Association, 1903.]

The creameries and cheese factories are classed as follows:

	Proprietary.	Cooper- ative.	Not stated.	Number of counties repre- sented.
190 creameries	83	102	5	14
51 cheese factories	26	24	1	8

WISCONSIN

[J. Q. Emery, State dairy and food commissioner.]

There were in Wisconsin, in 1902, 1,151 creameries and 1,826 cheese factories. Estimates are as follows:

Butter made in creameries and on farms, pounds.....	118,750,000
Cheese made, pounds.....	90,360,000
Value of butter	\$23,745,000
Value of cheese	\$9,036,000
Value of condensed milk	\$347,000
Value of by-products sold.....	\$700,000
Value of milk and cream consumed	\$8,500,000
Increase in value of stock.....	\$2,500,000
Total value of dairy products	\$55,000,000

The Swiss cheese industry, which had its inception when a little colony of Swiss settled in Green County over fifty years ago, has developed until that county alone has over 243 factories, and the output of 500 factories reaches 15,000,000 pounds annually, contributing materially to the prosperity of that portion of the State.

STATISTICS OF CATTLE, COWS, AND DAIRY PRODUCTS OF FOREIGN COUNTRIES.

Table XXIII gives the number of cows and cattle in countries where such statistics have been collected. In most cases figures are given for two dates, showing increase or decrease in stock raising. The figures are taken from official documents and such reliable publications as the Agricultural Returns for Great Britain, the Statesman's Year Book, Mohr's Statistics of Stock Raising and Dairying in Foreign Countries (Hamburg), and special consular reports.

TABLE XXIII.—*Cows and cattle of foreign countries for stated years.*

[From various authorities.]

Countries.	Year.	Cows.	All cattle.	Year.	Cows.	All cattle.
		<i>Number.</i>	<i>Number.</i>		<i>Number.</i>	<i>Number.</i>
Algeria	1891		1,233,051	1899		1,045,102
Argentina	1888		21,961,657	1895	1,800,799	21,701,526
Australasia	1892	1,249,720	12,343,353	1899	1,486,832	11,049,065
Australia	1892	1,029,720	11,522,052	1899	1,143,276	9,838,626
New South Wales	1892	365,110	2,147,074	1899	399,327	1,967,081
Queensland	1892	125,000	6,591,416	1899	a 131,000	5,053,836
South Australia	1892	79,420	625,887	1899	84,498	526,524
Victoria	1892	417,177	1,824,704	1901	521,612	1,602,384
Western Australia	1892	8,000	162,886	1899	22,500	297,081
Tasmania	1892	35,013	170,085	1899	41,482	160,204
New Zealand	1892	220,000	821,801	1900	372,416	1,256,680
Austria	1890	4,254,303	8,643,936	1900	4,744,608	9,506,626
Belgium	1895	802,271	1,420,978	1901	834,025	1,646,320
Brazil	1891		17,000,000	1900		a 20,000,000
Canada	1891	1,857,112	4,120,586			
British Columbia	1891	17,504	126,919	1901		125,002
Manitoba	1891	82,712	230,696	1902		282,843
New Brunswick	1891	106,649	204,692			
Nova Scotia	1891	141,684	324,772	1901		316,174
Ontario	1894	876,167	1,940,673	1902	1,010,746	2,562,584
Quebec	1891	549,454	969,312			
Prince Edward Island	1891	45,849	91,695	1901		112,777
The Territories	1891	37,003	231,827	1901		591,739
Cape of Good Hope	1893		1,929,800	1899	a 650,000	1,077,044
Ceylon	1893		1,062,776	1900		1,397,818
Chile	1892		311,000	1898		b 500,000
Cuba	1892		2,485,766	1901		2,455,788
Denmark	1888	954,250	1,459,527	1902	1,100,000	c 1,743,440
Finland	1890		928,276	1899		1,457,423
France	1890	6,509,325	13,562,685	1901	8,068,857	14,673,810
Germany	1892	9,946,164	17,555,694	1900	10,458,631	18,939,692
Hungary	1880	2,035,217	5,311,378	1895	2,185,224	6,738,365
India	1890		49,635,590	1900	21,816,961	d 51,104,177
Italy	1881	2,356,556	4,783,232	1890		a 5,000,000
Jamaica	1893		110,720	1899		118,900
Japan	1890	613,522	1,044,976	1900	649,942	1,261,214

a Estimated.

b Are reared annually.

c 1898.

d Does not include buffaloes.

TABLE XXIII.—*Cows and cattle of foreign countries for stated years—Continued.*

Countries.	Year.	Cows.	All cattle.	Year.	Cows.	All cattle.
		<i>Number.</i>	<i>Number.</i>		<i>Number.</i>	<i>Number.</i>
Netherlands.....	1890	900,500	1,532,800	1899	968,400	1,646,500
Newfoundland.....	1891		23,822	1899	10,863	
Norway.....	1875	741,598	1,016,617	1900	689,563	950,201
Paraguay.....	1891		861,964	1900		2,743,665
Poland.....	1888		3,013,392	1900		3,003,629
Roumania.....	1890		2,520,380	1900	1,838,089	2,589,040
Russia in Europe.....	1888		24,609,264	1898		43,586,900
Servia.....	1895	289,501	915,428	1900	6300,000	942,087
Spain.....	1880		2,460,253	1895		2,217,659
Sweden.....	1890	1,578,927	2,399,491	1899	1,766,915	2,582,555
Switzerland.....	1886	663,102	1,212,538	1901	739,922	1,340,375
United Kingdom.....	1895	3,937,590	10,753,314	1902	4,084,305	11,376,969
England.....	1895	1,786,370	4,472,565	1902	1,841,356	4,611,937
Scotland.....	1895	423,967	1,177,947	1902	488,890	1,222,165
Ireland.....	1895	1,433,960	4,358,041	1902	1,510,701	4,782,204
Wales.....	1895	275,483	703,824	1902	275,880	721,874
Isle of Man.....	1895	7,399	21,136	1902	6,910	20,271
Channel Isles { Jersey.....	1895	6,748	12,282	1902	6,686	11,936
{ Guernsey.....	1895	3,663	7,519	1902	3,882	6,582
United States.....	1890	16,511,950	51,363,572	1900	18,112,707	69,438,758
Uruguay.....	1892		5,487,604	1901		6,826,601

a Exclusive of Poland.

b Estimated.

c Includes Alaska and Hawaii.

Some countries have a very small number of cattle in proportion to the population. The number of cows alone does not show the condition of the dairy industry, however, for in many places large numbers of buffalo, reindeer, goats, etc., supply milk and meat.

The United States is far in the lead of all foreign countries in the extent of its stock-raising interests and the annual value of its dairy products.

Dairying is carried on extensively and successfully in certain parts of Europe, and some statistical information regarding this industry is accessible, although far from being as complete as could be desired.

CANADA.

Canada has made rapid advances in the dairy industry in recent years. Cheese is the product of greatest commercial importance, although butter making for export is also receiving much attention. The following table illustrates this development:

Exports of dairy products from Canada.

Year.	Butter.		Cheese.	
	<i>Pounds.</i>	<i>Dollars.</i>	<i>Pounds.</i>	<i>Dollars.</i>
1893.....	7,036,013	1,296,814	133,946,365	13,407,470
1900.....	25,259,737	5,122,156	185,984,430	19,856,324
1901.....	16,335,528	3,295,663	196,926,397	20,686,951
1902.....	27,855,978	5,660,541	200,946,401	19,686,291

Almost all the butter and cheese exported goes to Great Britain, the export of butter to that country in 1901 being valued at \$3,142,353, and cheese at \$20,609,361, and in 1902 \$5,459,300 for butter and \$19,620,239 for cheese.

ONTARIO.

Ontario is the leading dairy province of Canada. It is about four times as large as Michigan and has less than half as many cows per square mile. It produces about one-fifth as much cheese per square mile as New York State.

Particulars of cheese and butter factories in Ontario, 1901.

Product.	Number of factories.	Amount made.	Gross value.	Milk required to make 1 pound.	Value per pound.	Amount paid to patrons.	Average number of patrons.
		<i>Pounds.</i>	<i>Dollars.</i>	<i>Pounds.</i>	<i>Cents.</i>	<i>Dollars.</i>	
Cheese	1,167	134,942,517	12,269,073	10.63	9.09	10,814,538	59,377
Butter	286	9,047,260	1,798,264	.....	19.88	1,549,576	19,896

Ontario in 1902 had 2,562,584 head of neat cattle, 1,010,746 of these being cows. Using the population of 1901, we find 117.4 neat cattle and 46.3 cows per 100 persons. The number of cows per 100 persons is greater than in any of the European countries, although the cows constitute only 39.4 per cent of the total cattle.

PRINCE EDWARD ISLAND.

In Prince Edward Island in the season of 1901, 37,230,775 pounds of milk was made into cheese in 43 factories. The amount of cheese made was 3,597,689 pounds, showing an average of 10.40 pounds of milk to one pound of cheese, and the average price of cheese for the season was 9.01 cents per pound. The cost of manufacturing was \$2.11 per 100 pounds, and the net value of the milk per 100 pounds varied from 60 to 70 cents. Twenty-seven of these cheese factories made butter, and, together with 5 creameries, produced 633,679 pounds of butter, valued at \$132,792.

NEW BRUNSWICK.

New Brunswick in 1902 had 55 cheese factories with an output of 1,910,733 pounds. This was valued at 9.92 cents per pound and 10.14 pounds of milk were required for 1 pound of cheese. There were 40 creameries which made 750,911 pounds of butter, with an average selling price of 20.37 cents per pound, and 21.52 pounds of milk were required for 1 pound of butter.

MANITOBA.

The cheese factories in Manitoba in 1902 made 1,093,653 pounds of cheese, selling at 10.19 cents per pound, while the creameries made

1,406,450 pounds of butter, selling at 18.60 cents per pound. In 1901 about 2,748,090 pounds of butter were marketed by farmers, at an average value of 14.04 cents per pound, and in 1902, 2,509,425 pounds at an average of 14.92 cents per pound.

NOVA SCOTIA.

Nova Scotia in 1901 had 7 cheese factories, 8 creameries, and 6 combined butter and cheese factories. The products from these were 316,180 pounds of cheese and 266,109 pounds of butter.

BRITISH COLUMBIA.

British Columbia in 1901 had 8 creameries which produced 601,329 pounds of butter.

THE TERRITORIES.

The Territories (of Canada) had 19 creameries in 1902. Their product was 586,171 pounds of butter, valued at \$116,827, which was an average of 19.93 cents per pound.

GREAT BRITAIN AND IRELAND.

The number of neat cattle and cows for the last ten years are compared in the following table:

Year.	Number of neat cattle.	Number of cows.	Year.	Number of neat cattle.	Number of cows.
1892.....	11,519,417	4,120,451	1900.....	11,455,009	4,096,682
1896.....	10,941,655	3,958,762	1902.....	11,338,180	4,066,827

In 1902, for every 100 persons there were 27.3 neat cattle and 9.8 cows.

Estimated production of milk, butter, and cheese.

Period or year.	Total number cows and heifers in milk.	Number of cows per 1,000 population.	Number of cows giving milk all the year (75 per cent of total).	Estimated total milk produced, tons. ^a	Estimated total butter produced, tons. ^b	Estimated total cheese produced, tons. ^c
1887 to 1891, average for 5 years.....	3,937,556	105.8	2,953,167	7,355,607	84,063	144,485
1892 to 1896, average for 5 years.....	3,991,269	102.8	2,993,515	7,098,586	81,094	137,999
1897 to 1901, average for 5 years.....	4,070,332	100.0	3,052,529	7,502,301	85,731	144,577
The year 1900.....	4,096,682	100.1	3,072,512	7,753,484	88,611	152,300
The year 1901.....	4,102,061	98.7	3,076,546	7,236,036	82,653	142,136

^a Produced in 52 weeks by 75 per cent of total herd, at 49 hundredweight, or 531 gallons, per cow.

^b Produced in 52 weeks, taking 32 per cent of total milk to yield 80 pounds of butter per ton of milk.

^c Produced in 52 weeks, taking 20 per cent of total milk to yield 220 pounds of cheese per ton of milk.

Homemade English Cheddar retails at 20 cents per pound, while imported Cheddar cheese is 13 cents per pound. Butter for general use retails very uniformly at 24 cents per pound throughout the year. About 15 gallons of milk are consumed yearly per capita.

The returns from 195 cooperative dairy societies (creameries) in Ireland for 1901 were as follows:

Membership	33,064
Sales of butter, value in pounds sterling	717,902
Milk received, gallons	37,161,892
Butter produced, pounds	15,345,942
Milk per pound of butter, gallons	2.4
Average price milk per gallon, pence	3.97
Average price per pound of butter, pence	11.22
Cost of making, per pound, pence	1.29

Importation in hundredweights (112 pounds) by the United Kingdom.

Year.	Butter.	Cheese.	Condensed milk.	Year.	Butter.	Cheese.	Condensed milk.
1892.....	2,183,009	2,232,817	481,374	1900.....	3,378,516	2,705,878	.....
1895.....	2,825,662	2,133,819	549,394	1901.....	3,702,810	2,586,837	921,020
1898.....	3,209,153	2,339,452	817,274	1902.....	3,974,177	2,546,384	.....

The imports of butter by countries in 1902 were as follows:

	Cwts.		Cwts.
Australia	80,460	Holland	393,261
Canada	285,765	Russia	489,091
New Zealand.....	157,993	Sweden	191,591
United States	54,458	Other countries.....	177,967
Denmark	1,703,032		
France	414,141	Total	3,974,177
Germany	26,418		

The cheese imported from Canada in 1902 amounted to 1,709,566 hundredweights. Nearly all the imported cheese is of the Cheddar variety.

In 1901 the greater part of the condensed milk came from France (of Swiss origin), 340,118 hundredweights; the Netherlands, 341,209 hundredweights; Norway, 100,036 hundredweights; and the United States, 73,016 hundredweights.

VICTORIA.

Victoria, the leading dairy colony of Australia, had, in 1901, 1,602,384 neat cattle, of which 521,612 were cows; this was 133.4 neat cattle and 43.4 cows per 100 persons. There were 238 butter and cheese factories, with 372 branches.

The approximate output, consumption, and export of butter is as follows:

	1899.	1900.	1901.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Output	69,144,187	72,180,969	65,154,075
Consumption	32,906,718	34,387,798	36,007,682
Export	36,237,469	37,793,161	29,146,393

NEW SOUTH WALES.

New South Wales had 420,148 dairy cows in 1900, yielding 149,153,000 gallons of milk. Of this, 114,069,000 gallons were used for butter and 3,559,000 gallons for cheese. The average yield of milk per cow was 355 gallons per annum. The butter exported in 1900 amounted to nearly 8,500,000 pounds, and the total value of dairy products is estimated at \$13,756,187.

NEW ZEALAND.

The government of New Zealand is doing all it can to promote the dairy industry. Perhaps no country is its superior for the production of milk from natural grasses and fodders, while the climate is so favorable that the cattle do not require to be wintered in expensive stables. During the year ended March 31, 1902, the exports of butter and cheese amounted to 219,493 hundredweights and 86,476 hundredweights, respectively, valued at over \$1,000,000. This was an increase of 20 per cent over the previous year.

In 1900 there were 1,256,680 neat cattle, of which 372,416 were cows; this was 151.5 neat cattle and 44.9 cows for every 100 inhabitants, the number of cows being 21.7 per cent that of the total cattle.

DENMARK.

Denmark is about one-third the size of New York. The neat cattle and cows of Denmark for previous years are:

Census year—	Total number of cattle.	Number of cows.
1881	1,470,078	898,790
1888	1,459,527	954,250
1893	1,696,190	1,011,098
1898	1,743,440	1,067,139

By taking the population of 1901, for every 100 persons there are 70.7 neat cattle and 43.4 cows, the cows forming 61.2 per cent of the total cattle.

In 1902 there were in Denmark 1,250 creameries, 20 cheese factories, and 500 combined butter and cheese factories. Very little butter is made on small farms, but large estates have creameries of their own. A very large part of the creameries of Denmark, however, are cooperative establishments. The 1,100,000 milch cows produced 653,833,-125 gallons of milk—an average of 594 gallons per cow.

The total butter made in 1902 amounted to 181,879,500 pounds, 26 pounds of milk being required for 1 pound of butter. The butter exports for the year ended October 30, 1902, were 193,061,998 pounds, and the imports 54,138,811 pounds, leaving a net exportation of 138,823,187 pounds. The imports were mainly Finnish and Russian (Siberian) butters, intercepted by enterprising merchants for reexport. The Danish imports and exports of cheese have been, in recent years, as follows: Imports in 1894, 816,704 pounds; in 1899, 1,248,800 pounds; and in 1901, 1,086,400 pounds; exports in 1894, 23,408 pounds, and in 1901, 61,600 pounds.

The export of oleo, or margarine, from Denmark is not permitted, although large quantities are produced, under Government regulations, for consumption within the country, and there is a considerable import. The Danes consume 18½ pounds of margarine per capita, this rate having risen from 5½ pounds per capita within ten years.

A striking feature in the dairying of Denmark is the great number of small farms and small dairy herds. This is well shown by the following table:

Number of farmers owning 1 cow.....	20,500
Number of farmers owning 2 cows.....	27,700
Number of farmers owning 3 to 5 cows.....	26,800
Number of farmers owning 6 to 9 cows.....	25,400
Number of farmers owning 10 to 14 cows.....	19,800
Number of farmers owning 15 to 29 cows.....	29,800
Number of farmers owning 30 to 49 cows.....	5,800
Number of farmers owning 50 to 99 cows.....	1,440
Number of farmers owning over 100 cows.....	6,762

SWEDEN.

The development of the cattle industry will be shown by the following figures:

Census year.	Total number of cattle.	Cows.
1880.....	2,227,757	1,409,236
1890.....	2,399,491	1,578,927
1895.....	2,540,225	1,705,604
1899.....	2,583,065	1,766,915

For each 100 persons there are now 50.3 neat cattle and 34.4 cows, the cows forming 68.4 per cent of the total number of cattle. In 1902 over 700,000,000 gallons of milk was produced, and 121,253,000 pounds of butter made, of which about 42,000,000 pounds were exported.

There are 1,215 creameries, 287 cheese factories, and 186 combined butter and cheese factories. The total quantity of milk handled by these factories was 1,857,228,670 pounds. From this was made 57,570,963 pounds of butter, 7,199,637 pounds full-cream cheese, 3,226,145 pounds half-cream cheese, 403,021 pounds quarter-cream cheese, and 5,563,401 pounds skim-milk cheese. The number of butter and cheese factory patrons was 68,947. The average yearly consumption of butter in Sweden is estimated at only 12 pounds per capita. The Government supports a dairy college, two dairy schools, and several stations for training dairy maids. There are also a number of small dairy schools supported by large landed proprietors.

NORWAY.

The number of cattle and of cows of previous years are as follows:

Census year.	Total number of cattle.	Cows.
1865.....	953,036	690,777
1875.....	1,016,617	741,598
1890.....	1,006,497	706,925
1900.....	950,201	689,563

In the year last named there were for every 100 persons 45.1 neat cattle and 31.7 cows. Of the total number of cattle 72.6 per cent are cows.

Norway has about 650 creameries. The product in 1901 was 7,716,100 pounds of butter and 9,122,635 pounds of cheese. The Government maintains 9 creamery schools and 1 school for cheese making, besides appropriating about \$2,000 for the advancement of the creamery industry abroad. The value of the butter imported in 1901 was \$119,528, while that exported was \$701,892. The product of 3 condensed-milk factories is exported.

THE NETHERLANDS.

The cattle industry of this country is shown in the following table:

Year.	Total number of cattle.	Cows.
1890.....	1,532,800	900,500
1896.....	1,583,400	916,900
1899.....	1,646,500	958,400

There were, in 1899, 32.3 neat cattle and 18.8 cows per 100 inhabitants, and 58.2 per cent of the cattle were milch cows.

The Netherlands had, in 1900, 873 creameries and 76 cheese factories. The total butter and cheese production was as follows:

Where produced.	Butter.		Cheese.	
	1899.	1900.	1899.	1900.
On farms	68,932,554	65,949,620	110,873,664	113,469,620
In creameries.	52,831,540	54,807,036	36,033,487	44,240,035
In cheese factories	79,867	118,628	6,793,024	8,269,554
Total	121,843,961	120,875,284	153,700,175	165,979,209

It is thus seen that cheese is generally and largely made in the establishments classed as creameries. This means a considerable production of skimmed or partly skimmed cheese. Imports and exports of cheese are thus reported: Imports in 1895, 249,760 pounds; in 1901, 293,664 pounds; exports in 1895, 36,627,360 pounds; in 1901, 52,971,072 pounds. In 1902 the exports to Great Britain were 31,810,016 pounds of cheese and 44,045,232 pounds of butter.

BELGIUM.

Belgium has four-fifths as many milch cows as the State of Pennsylvania, although it is only one-fourth the size of that State. The following figures show the growth of the cattle industry:

Year.	Total number of cattle.	Cows.
1866.....	1,242,445	738,732
1880.....	1,382,815	796,178
1895.....	1,420,978	802,271
1900.....	1,657,494	828,445

In 1900 there were only 24.6 neat cattle and 12.3 cows per 100 inhabitants. The dairy interests are extensive, but fall considerably short of supplying the demand. In 1901 the butter imports and exports were 7,833,241 pounds and 5,926,860 pounds, respectively. The average yearly per capita consumption of butter is 25 pounds. Cooperative creameries are numerous and prosperous in Luxembourg. Imports of cheese amounted to 5,759,040 pounds in 1893 and to 9,924,560 pounds in 1901, while the exports were 81,760 pounds in 1893 and 69,664 pounds in 1901.

FRANCE.

France is over four times as large as the State of New York and has one and one-fourth times as many cows per square mile. The growth of the cattle and dairy industry has been as follows:

Year.	Total number of cattle.	Cows.
1885.....	13,104,970	6,414,487
1890.....	13,562,686	6,509,325
1895.....	13,233,828	6,359,796
1900.....	14,520,830	7,819,682

In 1901 there were 37.7 neat cattle and 20.7 cows per 100 inhabitants. The milk produced in 1901 amounted to 2,076,079,299 gallons, valued at \$223,758,093, or 10.92 cents per gallon, from 8,068,857 cows. The decennial average 1892-1901 was 2,092,919,265 gallons, valued at \$232,962,981, or 11.12 cents per gallon, from 6,674,863 cows.

For the production of milk France and England are both entitled to occupy third place in Europe. England produces as much milk with a smaller number of cows.

In 1901 the departments furnishing the most milk were:

	Cows.	Gallons.	Cents per gallon.
Nord	203,074	107,442,222	12.39
Deux Sèvres.....	101,579	95,555,572	9.00
Ille-et-Vilaine	443,023	80,113,119	11.65
Calvados	127,809	69,048,147	11.47
Seine Inférieure.....	170,941	68,870,045	9.71

The lowest price for milk is obtained in Aube, Haute-Marne, and Finistère (7.3 cents per gallon); the highest, 24.84 cents per gallon, in the department of Seine.

There are 427 creameries and 1,044 cheese factories. In 1902 the imports were 11,813,349 pounds of fresh butter and 147,047 pounds of salted butter, valued at \$3,030,048, while the exports of butter were 29,847,418 pounds, valued at \$14,989,175, giving a surplus of over \$11,500,000. This is due to the small per capita butter consumption, which is probably less than 5 pounds, or not one-fourth of that of the United States. Cheese, on the other hand, is one of the most common articles of food, being made in great variety and consumed in very large quantities. The commerce in cheese is reported as follows, for recent selected years: Imports amounted to 38,111,913 pounds in 1883, 27,871,642 pounds in 1893, and 42,034,017 pounds in 1901, while the exports were 8,377,235 pounds in 1883, 12,388,732 pounds in 1893, and 17,795,097 pounds in 1901.

France in 1901 imported 98,440 pounds of milk sugar and about 1,000,000 pounds of casein.

SWITZERLAND.

The increase in the cattle industry is shown by the following table:

Year.	Total number of cattle.	Cows.
1876.....	1,035,930	592,463
1886.....	1,212,538	663,102
1896.....	1,306,696	688,052
1901.....	1,340,375	739,922

In 1901 there were 40.4 cattle and 22.3 cows for every 100 persons. In this year the milk product amounted to 497,525,000 gallons of cows' milk and 19,875,000 gallons of goats' milk. The average yearly per capita consumption of milk is calculated as 225 liters (238 quarts). There was used 175,673,050 gallons for making cheese and butter, fully two-thirds of this being for cheese. About 66,042,500 gallons was converted into condensed milk. There are about 5,400 cheese dairies, half of which are situated in the mountains. The trade of 1901 was as follows:

Product.	Imports, 1901.		Exports, 1901.	
	<i>Kilos.</i>	<i>Francs.</i>	<i>Kilos.</i>	<i>Francs.</i>
Butter.....	2,323,100	5,585,305	42,900	136,882
Soft cheese.....	1,241,100	1,472,940	36,700	57,823
Hard cheese.....	686,100	791,095	27,213,200	43,976,458
Condensed milk.....	4,900	4,900	30,724,600	28,941,266

Whey butter, made from the fat which separates from the curd during the cooking process in the manufacture of Emmenthaler cheese, is used extensively, and retails at 30 cents a pound.

GERMANY.

The cattle industry has increased as follows:

Year.	Total number of cattle.	Cows.
1883.....	15,786,764	9,086,906
1892.....	17,555,694	9,946,164
1900.....	18,939,692	10,458,631

Using the census figures of 1900 we find that there are 33.6 neat cattle and 18.6 cows per 100 persons. There are in Germany about 6,375 creameries and cooperative societies of dairymen. Most of these make butter, although many only cooperate in collecting and shipping milk to market, or in managing city milk depots. This country has, in

addition, nearly 1,000 private or "estates" dairies, which use steam power and are of sufficient size to be mentioned with the creameries. Of the whole number one-third are in the northwestern German States, one-sixth in Prussia, and an equal portion in Brandenburg and Pomerania.

Statistics show the imports and exports of butter to be as follows, the weights being in kilograms:

Year.	Imports.	Exports.
	Kilos.	Kilos.
1870.....	3,410,000	17,880,000
1888.....	5,170,000	13,650,000
1898.....	8,580,000	2,830,000
1900.....	15,720,000	2,520,000
1901.....	18,007,900	2,466,400

The exports are thus seen to be steadily decreasing, while the imports are increasing in greater proportion.

Butter is imported principally from Denmark, Holland, and Russia. The Berlin market demands a fresh or half-salted butter, while Hamburg requires it very highly salted and preserved with antiseptics. The butter packer at Hamburg mixes good and bad butter together, using strong brine to give it good keeping qualities and also to add weight. Some of these butters contain as high as 30 per cent moisture.

The cheese imported in 1901 amounted to 16,669,700 kilograms, while that exported was 1,456,800 kilograms, leaving a net import of 15,212,900 kilograms. In the same year 1,700 kilograms of condensed milk was imported, while 2,929,700 kilograms was exported.

RUSSIA.

Russia, with its new grass lands in Siberia and now served by the transcontinental railway, shows signs of rapid expansion. In 1900 there were 15 dairy schools in Russia. The dairy development is very largely under the management of Danes. The department of agriculture has allotted \$39,000 to encourage dairy production and export in Siberia. This amount is to be used for the support of creamery instructors to maintain examining laboratories and educational courses, and in the organization of creameries in Western Siberia. Russia exported, in 1902, 2,274,000 poods, or about 82,118,000 pounds, of butter, the exports to England being about 17,500 tons, while in 1892 they were only about 1,000 tons. This increase is due in a large measure to the new Siberian product, which has a good reputation for purity. The price of table butter at Tomsk is about 16½ cents per pound, while the second grade sells at 10 cents per pound. In 1901 Russia imported 1,375,920 pounds of cheese and exported 807,184 pounds.

AUSTRIA.

The cattle industry has increased as follows:

Year.	Total number of cattle.	Cows.
1869.....	7, 425, 212	3, 831, 136
1880.....	8, 584, 077	4, 138, 625
1890.....	8, 643, 936	4, 254, 303
1900.....	9, 506, 526	4, 744, 608

Using the census of December 31, 1900, we find that there are 36.4 cattle and 18.1 cows per 100 persons. In Austria there are 774 creameries and cheese factories. In Tyrol alone there are 504 Gruyère cheese-making creameries.

HUNGARY.

The number of cattle has increased as follows:

Year.	Total number of cattle.	Cows.
1870.....	5, 279, 193	2, 052, 488
1880.....	5, 811, 378	2, 035, 217
1895.....	6, 738, 365	2, 185, 224

The extent of the dairy industry of Austria-Hungary in 1901 was as follows:

Product.	Imports.	Exports.
	<i>Kilos.</i>	<i>Kilos.</i>
Butter.....	66, 700	7, 474, 800
Cheese.....	3, 296, 400	364, 100

GREECE.

Dairying in this country is not extensive, yet in 1901 Greek cheese valued at \$16,622 and Greek butter valued at \$343 were imported by the United States. Nearly all the butter was received in the melted state and was unsalted. There are a few dairies that keep cows and use dairy machinery. The amount of cows' butter made in the vicinity of Athens is estimated at 103,660 pounds, while 710,000 pounds of imported butter is consumed there.

The natives use the milk of the goat and sheep, believing it to be more healthy than that of the cow.

ITALY.

In 1890 it was estimated that there were 5,000,000 cattle and 1,800,000 goats. The goats are milked at the door of the consumer. Very little butter is used, olive oil taking its place in cooking. The trade in dairy products in 1901 was as follows:

Product.	Imports.	Exports.
	<i>Kilos.</i>	<i>Kilos.</i>
Butter	332,600	6,061,200
Cheese	4,807,700	10,933,600
Condensed milk	7,300	16,300

ARGENTINA.

Dairying in Argentina is fast increasing. Since 1895 there have been established several large butter factories, besides importing houses concerned in the introduction of butter-making machinery. Statistics for 1901 show that there are 523 dairies and about 300 cheese factories. One "dairy" is alone capable of producing 5 tons of butter per day. The exports of butter in 1901 had increased to over 3,000 tons, of which Great Britain received 3,281,889 pounds, at an average price a little more than 24 cents per pound. The exports of butter in 1902 had increased to 9,021,026 pounds. The principal dairy is the Granja Blanca, with nearly 5,000 cows in two herds (Las Heras and Escobar farms). This establishment sells pasteurized, maternized, and sterilized milk, as well as condensed milk, kefir, natural milk, butter, casein, and soap.

BRAZIL.

The dairy industry of Brazil is yet in its embryonic state. There is a decided lack of milch cows, although the grazing lands are extensive. That very excellent butter can be made is shown by the product of its German colonies in the south. In 1901 Brazil imported over 1,700,000 pounds of butter, nearly two-thirds of this coming from France.

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(Continued from second page of cover.)

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ANIMAL INDUSTRY—BULLETIN NO. 56.

D. E. SALMON, D. V. M., Chief of Bureau.

DIGESTION EXPERIMENTS WITH POULTRY.

BY

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PREPARED UNDER THE SUPERVISION OF

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1904.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., December 22, 1903.

SIR: I have the honor to transmit herewith a manuscript entitled "Digestion Experiments with Poultry," by E. W. Brown, Ph. D., assistant in the Biochemic Division, and recommend its publication as Bulletin No. 56 of this Bureau. These tests were carried out with the object of determining the digestibility of corn, oats, wheat, and meat, respectively, for chickens. The investigations heretofore published along this line for poultry are very limited, especially when compared with those for mammals. The difficulties attendant upon experiments of this nature with the former class of animals, owing to their physiological formation, are no doubt largely accountable for the small amount of literature extant upon the subject. Hence the present volume is of timely interest.

Some practical suggestions to poultrymen are included, bearing on the dietary values of the different properties of the foods above mentioned, and also on the digestive value of the grains when used in combination.

The four half-tones and two text figures are necessary as illustrations.

Respectfully,

D. E. SALMON,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary.

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DIGESTION EXPERIMENTS WITH POULTRY.

PREFATORY.

INTRODUCTION.

The study of the digestion of feeding stuffs has not been extended equally to all classes of farm animals. The great bulk of the available data in this connection relates to ruminants, horses, and hogs, while but meager attention has been given to poultry. The practical importance of investigations designed to supply this deficiency is obvious. There has been a great increase in the poultry industry during recent years, with a growing demand for information regarding the care and management of the different kinds of domestic fowls. Feeding standards, based on the digestion coefficients of the various foodstuffs, have not been available, and poultrymen have especially felt the need of such as an aid toward attaining the most economic and productive methods in the nutrition of their stock. Many of the experiment stations have considered questions of poultry nutrition, and much of value has been accomplished. Aside from a single publication, however, these investigations have been limited to feeding experiments. Such observations are of value only as regards the particular diet under consideration and fail to afford the data necessary for the rational combination of a wide choice of nutrients. It is, therefore, very desirable that the digestion coefficients of a wide variety of poultry foods be made accessible under an extensive range of conditions. On such a basis feeding standards might be adopted which would prove a source of much economy. By the use of such standards much wastefulness caused by feeding new or untried feeding stuffs might be avoided and poultrymen would be enabled to incorporate into the diet only those materials which possess relatively the highest digestibility at relatively the lowest cost.

The published data at hand relating to digestion coefficients for poultry are insufficient in number and variety to justify the adoption of feeding standards or even to arrive at definite conclusions regarding the availability of the nutrients of the foods tested. This lack of literature on the digestive capacity of poultry is in marked contrast with the abundant data available for other classes of farm animals. The main reason for this seems to lie in certain difficulties of technique encountered in digestion experiments with poultry. This is obvious

when some of the conspicuous differences in anatomical structure between birds and mammals are considered.

The anatomical structure of the bird is relatively much less complex than that of the mammal. The genito-urinary apparatus is notably simpler in structure. The urine is not temporarily stored in a bladder, as in mammals, but is conveyed directly from the kidneys through the ureters to the cloaca, there to be admixed with the fecal matter from the intestines. The structure of the alimentary canal of the bird suggests that the digestive process is rapid and that it partakes of features associated with both the carnivora and herbivora. Thus the relative shortness of length is a carnivorous characteristic, while the character of the diet and the thorough comminution of the food in the gizzard are features more akin to the herbivorous type.

The fact that the urine and feces are excreted together has formed the chief obstacle to progress in the performance of digestion experiments with poultry. As the accurate analysis of the fecal matter is essential for the estimation of the digestion coefficients, it is obvious that the matter is seriously complicated by this admixture with the urine; and, while the same general principles are applied in the study of the digestion coefficients of birds and mammals, certain modifications in the collection and analysis of the excrement are required in the case of the former, and peculiar difficulties are met with which have hindered advance in this direction. The analytical procedure in digestion experiments with poultry would be greatly simplified and accurate results more readily obtained if the mixture of the urine and feces could be avoided.

The plan of the introduction of cannulae into the ureters, thereby separating the urine in a pure condition, might be attempted, but does not seem feasible for quantitative operations. Two investigators, whose experiments will be reviewed later, have established an artificial anus in the abdominal wall. It seems doubtful, however, whether such operative procedure can be followed without interference with the health of the fowl.

The separate collection of the urine and feces is absolutely essential to the estimation of such constituents of the food as are eliminated in the urine either partially or wholly in unchanged form. Under these conditions the quantity of urine excreted in the feces could not be determined, and therefore the calculation of the quantity excreted by the intestines would be excluded. Both the feces and urine include inorganic matter, and consequently the balance of income and outgo of this material, so far as the alimentary tract is concerned, could not be estimated, and the digestion coefficient for inorganic matter could not be ascertained. It has been demonstrated^{1-4a} that certain pentoses may be eliminated through the kidneys of mammals unchanged.

^aThe figures refer to bibliography at end of bulletin.

at least in part. If such were the case with birds the estimation of the digestion coefficient for pentosans would be very difficult. To render this accurate a method for the mechanical separation of the urine and feces should be devised.

Another difficulty encountered in digestion experiments with poultry is that the fowls are less adaptable to the general conditions of such experiments than other farm animals. The body temperature of birds is considerably higher than that of mammals and their respiration is much more rapid. Owing to their energetic temperament they do not bear confinement as well as many other classes of animals, and therefore some depression of the normal metabolic activity may be involved.

The problem of a satisfactory collection of the excrement has also delayed progress in investigations of the present character, and this is peculiarly complicated when taken in connection with the study of egg production as connected with the digestibility of feeding stuffs. Under such circumstances a collection apparatus would not be feasible, and it would seem to be necessary to maintain a constant watch over the animals so as to remove the excrement immediately after it has been voided.

PURPOSE OF THE PRESENT PAPER.

The chief components of poultry rations are represented by the grains, of which corn, oats, and wheat are probably most commonly used. Corn especially, may be said to form the basis of most poultry rations. It was planned to perform digestion experiments with each of these grains as the sole diet; also tests with a pure beef diet. Although these grains are commonly fed in combined rations, it seems to be of practical interest and value to determine their individual digestibility. In this way data may be acquired showing in what measure they form a balanced ration within themselves, or how they may be combined to the best advantage. It was also proposed to select a sufficient number of birds to determine, as far as possible, the factor of idiosyncrasy and unavoidable experimental error.

The present experiments are of a preliminary character only, and the number reported is insufficient to justify conclusions of a far-reaching character. This is doubly emphasized in view of the fact that so little investigation has been expended on the digestive processes of fowls. It is hoped that these experiments may serve as a starting point for a broad study of the availability of feeding stuffs for poultry, and it is believed that the experience gained in this investigation will be useful in future work.

CERTAIN FEATURES OF NITROGENOUS METABOLISM IN BIRDS.

DIFFERENCES BETWEEN THE NITROGENOUS END-PRODUCTS OF BIRDS AND MAMMALS.

There are several striking and significant points of difference between the urine of mammals and birds which must be taken into account, not

only in a study of nitrogenous metabolism, but also in a consideration of the digestibility of feeding stuffs in these classes of animals. A prominent peculiarity of avian urine is its relatively small content of water. This readily evaporates on standing in the open air, and the urine thus dried presents the familiar appearance of white flakes scattered irregularly throughout the fecal matter. Meissner⁵ observed many years ago that this white material, when examined under the microscope, presented the appearance of a mass of rounded amorphous particles, but when treated with a little acetic acid it immediately assumed a crystalline form and was apparently of uniform character. This substance is now known to be uric acid. The most important and prominent nitrogenous constituents of mammalian and avian urine are urea and uric acid, respectively. Broadly speaking, the quantitative proportions of these two substances are mutually reversed in the two excretions, that is, the urine of the bird contains only a very small fraction of urea and the proportion of uric acid to urea in the mammalian excretion is correspondingly small. Urea represents the great bulk of the excreted nitrogen of the mammal, while uric acid bears an analogous relation to the nitrogenous metabolism of birds. The uric acid of mammalian urine, however, does not owe its origin to the breakdown of proteid matter as such, but it is now believed to be largely derived through the metabolism of the nucleins. It is of suggestive interest that the high solubility of urea renders it particularly adaptable to the mammalian urine, which is of large volume, while uric acid, in view of its difficult solubility, is more suited to a urine of small water content.

The urine of birds differs strikingly from that of mammals in its comparative simplicity. Sir William Roberts⁶ comments on the matter as follows:

The chlorides, phosphates, and sulphates, the lime and magnesia salts, the pigment and large volume of water, all of which figure as prominent and even essential components of mammalian urine, are either wholly absent from the urine of birds and serpents or are only present in such minute traces as might be derived from the lubricating mucous and epithelial débris with which the secretion is incidentally mixed.

* * * But whereas in the urine of men and mammalia the quadriurates are only an insignificant item amid a host of other ingredients, the quadriurates constitute practically the whole of the renal excretion of birds and serpents. * * * The amorphous deposit is the physiological homologue of the entire renal activity of birds and serpents.

The above quotations are of a somewhat speculative nature, but in the main they express the general relations of the two types of animal excretions. In addition to uric acid and urea the urine of the bird may contain other substances in minute quantities. The exact comparative chemistry of the urinary output of birds and mammals has not been systematically investigated. The scanty literature on the

subject and a few observations of the writer in this connection are presented in another section of this paper.

THE PLACE OF FORMATION OF URIC ACID IN BIRDS.

It was early recognized that uric acid in the urine of birds possessed a significance akin to that of urea in mammals, namely, that this excretion embodied the form of the main nitrogenous end-product of proteid metabolism.

Much speculation has arisen relative to the mode and place of formation of uric acid in the organism of birds. In searching for an organ to which uric acid production might be delegated, physiologists early turned their attention to the kidney. Experiments were first performed on the hypothesis that the kidney is the sole seat of uric acid formation in the organism, and hence the removal of this organ would do away with uric acid production.

von Schröder⁷ succeeded in overcoming the great difficulties encountered in this work. In some of his experiments the kidney was merely excluded from the circulation, and uric acid was observed to accumulate readily in certain of the tissues and organs. Snakes,⁸ which, like birds, excrete the body nitrogen largely in the form of uric acid, lived from five to nine days after the removal of the kidneys, and deposits of uric acid or urates were found in several of the organs. These observations indicated that the kidney was, at least, not exclusively concerned in uric acid formation. This evidence is further sustained in the consideration of the comparative structure of the kidney in birds and mammals. A further statement of Sir William Roberts is of interest in this connection:

It is remarkable that the wide differences in the nature of the renal excretion in mammals and the sauropsida, respectively, should yet be associated with almost complete identity in the anatomical structure of the kidney. The kidney of the bird has a glomerular mechanism identical with that of the mammalian organ, * * * and yet practically the sole function of the organ of the bird, in contrast with the remarkably complex duties performed by that of the mammal, is to secrete quadriurates.

In view of this common structure of the kidney in the two classes of animals, it would hardly appear consistent that the organ should form large quantities of uric acid in the one case and relatively minute amounts in the other.

The preponderance of evidence so far accumulated has indicated that the place of urea formation in mammals is the liver. Minkowski⁹ endeavored to ascertain whether uric acid in birds—the physiological homologue of urea in mammals—is synthesized in that organ. In order to investigate whether an interrelation exists between uric acid production and the activity of the liver, he studied the influence of the removal of the liver on the composition of the urine. The difficulties

met with in mammals in the attempt to withdraw the liver from the circulation do not occur in birds, and it is not necessary to guard against the congested condition which occurs in mammals by establishing artificial communication with the ascending vena cava. In the case of birds, such a communication has a natural existence, as these animals have a vascular system in the kidney similar to the portal circulation in the liver. Taking advantage of this fact, Minkowski¹⁰ extirpated the liver from geese. In some cases the organ was merely cut off from the circulation. The large intestine was ligatured immediately above the cloaca in order to obtain the urine in a pure condition. The results of this experiment were so striking as to afford strong evidence that the liver was concerned with at least a part of the uric acid production in birds. The uric acid output, as a result of the operation, suffered a tremendous decrease. While the uric acid nitrogen normally corresponds to from 60 to 70 per cent of the total urinary nitrogen, under these conditions the percentage fell to from 3 to 6. This conspicuous reduction of uric acid nitrogen was largely replaced by a corresponding increase in the output of nitrogen in the form of ammonia. Prior to the operation the ammonia nitrogen comprised from 9 to 18 per cent of the total nitrogen of the urine, but subsequent to the removal of the liver this fraction reached from 50 to 60 per cent. Another very significant result was that this increased ammonia was present in the form of a salt of lactic acid, a substance which Minkowski was unable to detect in the normal urine. In these results he saw evidence that ammonia and lactic acid were produced by the oxidation of the proteid matter in the tissues, and that a synthesis of these two substances to uric acid was accomplished in the liver.

The findings of Minkowski's experiments have recently been fully corroborated by the observations of Lang.¹¹ Employing a slight modification of the operative procedure of Minkowski, he differentiated the urinary nitrogen into three fractions, namely, (1) ammonia, (2) uric acid and purin bases, (3) urea and creatin, assuming that the last-named body is present in the urine. The percentage of fall in uric acid elimination after the operation corresponded essentially to the results reported by Minkowski. Data are also recorded in this paper relative to the percentage of distribution of the above-named fractions of nitrogen relative to the total nitrogen in the normal urine of geese.

A recent communication by Kowalewski and Salaskin¹² lends support to the conclusions of Minkowski and Lang. Their experiments show that the liver takes a direct share in the formation of uric acid in birds. Not only ammonium lactate and ammonium salts of other organic acids, but such substances as arginine gave rise to its chemico-physiological production.

We find no investigation on record which has considered the

possible relation between uric acid formation and the activity of the spleen in birds. It was long thought that variations in the volume of the spleen were associated with fluctuations in the uric acid excretion in mammals, but later researches have proved that the spleen has no essential influence on the production of this excretion.

Mendel and Jackson¹³ estimated the uric acid output before and after extirpation of the spleen in dogs and cats. A comparable diet was fed during both periods. The daily excretion of uric acid remained practically unchanged after the operation. Noël Paton¹⁴ investigated the effect of splenectomy on the nitrogenous metabolism of dogs and found that practically no deviation from the normal appeared. Lo Monaco¹⁵ observed that the excretion of uric acid remained unaltered after extirpation of the spleen in man. These observations make it appear improbable that the spleen in birds bears an essential relation to uric acid formation.

It has been demonstrated that a small portion of the excreted uric acid of birds is formed independently of the liver. Thus Minkowski¹⁶ and Lang¹¹ found a small residuum of that substance in the urine after extirpation of this organ. It has been suggested—and there is some experimental evidence to support this view—that this fraction of the uric acid is formed under conditions similar to those obtaining in mammals. In the latter class of animals uric acid production is now regarded as sustaining an intimate relation to the character of the diet. It has been established during the last ten years that those organs of the body which are rich in cell nuclein—such as glands of the type of thymus, liver, spleen, etc.—occasion a marked rise in the elimination of uric acid when fed as a part or the whole of the daily diet. This rise in uric acid excretion is referable to the nuclein material which makes up the bulk of the cell nuclei. It has been shown that the nucleins when decomposed by boiling mineral acids yield xanthin bases—bodies closely related in structure to uric acid. The xanthin bases are regarded as direct precursors of uric acid formation. Abundant observation has proven that food materials free from nuclein, are practically without effect on the uric acid output in mammals. Variations in the amounts of uric acid excreted are attributed to fluctuations in the amount and character of the nuclein of the food and also fluctuations in the extent of the metabolism of body nucleins.

The question whether or not a fraction of the uric acid in the bird is referable to this mode of formation naturally suggests itself. von Mach¹⁶ has pointed out that the administration of hypoxanthin to geese deprived of the liver strikingly increased the elimination of the residuum of uric acid. This result is in harmony with the observations reported by Minkowski,¹⁷ Burian and Schur¹⁸ and Krüger and Schmid,¹⁹ all of whom noted a similar result with man. Milroy²⁰ has recently

shown that the ingestion of pure nucleins may lead to an augmented uric acid output in hens. The chickens selected for the experiments were operated upon for an artificial anus in order that the urine and feces might be separately excreted. These observations thus give evidence that a small portion of the uric acid of birds may be formed from precursors which give rise to an increased elimination of this excretive in mammals and also that some uric acid may be formed independently of hepatic activity. Variations in uric acid excretion in birds probably depend on two main factors—(1) the quantity of proteid and (2) the amount of nuclein contained in the food. The details of the exact relations of these two factors to uric acid production are yet to be determined.

The various facts cited above indicate that uric acid in birds is largely formed synthetically, while in man it results mainly from oxidation processes. Wiener's²¹ investigations suggest that uric acid may be to some extent formed synthetically in the liver of the ox. He found, however, that extracts of the kidney of the ox and the horse destroyed uric acid, while extracts of the liver of dogs and pigs produced a similar result. How far these observations would apply to the organs of birds can only be answered by experiment, but they tend to show that in the case of mammals the quantity of excreted uric acid is not necessarily an indication of the total amount formed in the body.

The circumstances pertaining to the formation of the small amount of urea in the urine of birds are entirely unknown. Minkowski¹⁰ estimated that this substance represented about 4 per cent of the total urinary nitrogen. It is significant that he found this proportion unaltered after extirpating the liver. This result affords evidence that urea is at least not entirely formed in the liver in birds, although its synthesis in the liver of mammals seems to be established.

THE ANTECEDENTS OF URIC ACID PRODUCTION.

The mode of formation of uric acid in birds has been an object of research with several investigators. As urea appeared to be a possible further physiological oxidation product of uric acid, it was early suggested that uric acid in birds might be derived from the same metabolic antecedents as urea in mammals.

Schultzen and Nencki²² observed that when leucin and glycocoll were administered to dogs they were eliminated as urea. Salkowski²³ confirmed these results, and von Knieriem²⁴ found that aspartic acid was transformed into urea in the same animals. The influence of ammonia salts on the output of urea in dogs and men has been considered by von Knieriem, and Salkowski studied the same question with reference to dogs and rabbits. Ammonium chloride was largely transformed into urea in the case of rabbits, while in the case of dogs and men the greater part of the salt was excreted in the same form

as ingested. The carbonate of ammonia was entirely transformed into urea in the organism of the three types of subjects. Feder and Voit²⁵ found that the acetate of ammonia led to the excretion of urea, while Lohrer²⁶ made the same observation with reference to the citrate salt.

Several observers^{27, 28} have reported experiments planned to study the relation of certain of the above-mentioned ammonium salts to uric acid formation in birds. Schröder²⁹ reported that the ammonium salts of acetic and formic acids were readily excreted in the altered form of uric acid. The chloride and sulphates, however, were removed by the kidneys unchanged, a fact which may account for the proportionately greater amount of ammonia that is normally excreted by the bird as contrasted with the mammal. Meyer and Jaffé²⁷ have individually reported that urea when administered to birds is eliminated as uric acid. Meyer claimed that part of the urea nitrogen appeared in the urine as ammonia salts. He found that the ingestion of uric acid led to its excretion in unchanged form with a slight rise in the body metabolism, while it has been shown that in the organism of mammals uric acid is more or less completely converted into urea. von Knieriem observed that amido acids, as leucin and tyrosin, increased the uric acid output in birds, while we have seen above that these bodies are precursors of urea in mammals.

When the data of these parallel experiments with birds and mammals are correlated, the following statement of Hopkins³⁰ is of suggestive interest:

The physiological differentiation whereby soluble urea takes the place of insoluble uric acid in accordance with the needs of an organism excreting a liquid urine is now known to occur at the final stages of metabolism. It is almost certain that in the main the waste products which leave the tissues are the same in birds and mammals. In the liver of the former these products are prepared for excretion by a change into the form of uric acid, while in the latter the hepatic influence produces urea.

A further characteristic difference in the nitrogenous metabolism of mammals and birds is brought out by a consideration of the comparative behavior of benzoyl compounds in the organism of these two classes of animals. It has long been known that the ingestion of salts of benzoic acid calls forth an increased output of hippuric acid in mammals. It is thus apparent that a synthesis of glycocoll and benzoyl compounds occurs somewhere in the body, and it is a fact of much interest that Bunge and Schmiedeberg³¹ were enabled to demonstrate that this process was carried out, at least in part, in the kidneys. When benzoyl compounds are administered to birds, the resulting excretion is quite different from that observed in the case of mammals. Jaffé³² observed that the condensation product of diamidovalerianic acid and benzoic acid is excreted—a compound known as ornithuric acid and analogous in structure to hippuric acid. The locality of formation of this homologue of hippuric acid has not been investigated,

but it appears not improbable that by analogy it is formed synthetically in the kidney.

The metabolism of sulphur in birds has been studied by Lang.³³ He investigated the effect of removal of the liver on the relationships of various forms of sulphur in the urine. The results were practically of a negative character, and he concluded that the liver plays no essential rôle in the elaboration of sulphur compounds in the form in which they appear in the urine.

REVIEW OF LITERATURE ON DIGESTIVE SECRETIONS OF BIRDS.

In accord with the lower evolutionary position of birds as contrasted with mammals, we find the structure of the digestive viscera in the former class of animals much less complex than in the latter. Comment has already been made on the simpler trend of nitrogenous metabolism in birds, and the less highly developed organization of the genito-urinary apparatus. The absence of mastication, the storage of food in the crop, and the peculiar muscular gizzard are all salient features characteristic of the digestive apparatus of the bird. The intestines fail to show the well-defined subdivisions so conspicuous in the mammalian organ. The caliber of this portion of the alimentary canal shows but little variation except at about the last inch of its length, where it widens before terminating at the cloaca. A peculiar feature of the intestines is the marked bilateral development of the cecum, which attains considerable length and joins the intestine a short distance above the cloaca. The writer has repeatedly observed in autopsies that the folds of mucous membrane or valvulae conniventes are especially conspicuous in this portion of the alimentary tract, thus indicating that a considerable share of the absorption of digestive products may take place in the ceca. In view of the anatomical considerations referred to above, it is suggested that the digestive changes of the foodstuffs may be of a simpler character than those noted in mammals.

THE CROP, ESOPHAGUS, PROVENTRICULUS, AND GIZZARD.

The function and structure of the crop have been considered by several investigators. Teichmann³⁴ reports that the mucous glands situated in the deeper portion of the mucous membrane are the only glandular structures present; no evidence was afforded that the crop secreted any digestive fluid. Klug³⁵ has reported that he found traces of acid and pepsin in the organ, derived from the stomach, and a part of the acid reaction may possibly also be accounted for by food fermentation. The purpose of the crop is to soften the food both by means of mucus carried down from the mouth and the secretion of the mucous glands of the organ itself. In 1786, Hunter³⁶ described the so-called "crop milk" of pigeons, and Hasse³⁷ in 1865 further dis-

cussed the same matter. This body fluid is often secreted by the crop of pigeons at breeding time and is furnished to the newly hatched birds. It is largely composed of mucous and cast-off epithelial cells.

Teichmann³⁴ also investigated the histological structure of the esophagus, proventriculus, and gizzard. The proventriculus appears as a dilation of the esophagus located at a short distance above the gizzard. The function of this organ seems to be to secrete pepsin and hydrochloric acid to be admixed with the food preparatory to the grinding of the material in the "muscular stomach," or gizzard. Broadly speaking, an analogy may be drawn between the cardiac, or main secretory portion of the stomach in man, and the proventriculus in birds; also between the more muscular, or pyloric, portion in the human organ and the gizzard of the bird.

THE GASTRIC JUICE.

By the use of an ingenious method, Réaumur³⁵ first obtained gastric juice from birds. Lead tubes containing sponges were introduced into the alimentary tract of certain birds of prey. The entrance of foreign indigestible bodies into the alimentary tract causes these animals to vomit. When the tubes were ejected, considerable fluid could be squeezed out of the sponges contained therein. As these experiments were performed some years prior to Schwann's discovery of pepsin, the observations were limited to the salty and bitter taste, the acid reaction toward litmus, and the softening and slightly solvent action of the secretion on meat. Réaumur also studied the action of the gastric juice by introducing into the stomach food materials inclosed in cylinders open at one end. He found that little solvent action resulted unless the food in question was subjected to the grinding action of the gizzard.

The observations of Réaumur were considerably extended by Spallanzani³⁶. Meat was shown to be completely dissolved in the gizzard of herbivorous birds, even when protected from the movements of the walls of the organ by inclosure in glass cylinders. The action of gastric juice collected by sponges as performed by Réaumur was studied outside of the body. Cheese, meat, bread, etc., were found to be almost completely dissolved. Those birds which possessed little mechanical power in the stomach secreted a notably active gastric juice. The action of this secretion was studied in a large variety of birds, as the vulture, owl, hawk, eagle, etc.

Tiedemann and Gmelin⁴⁰ collected gastric juice according to the method of the investigators heretofore named. They found that it always gave an acid reaction, and, in addition to the solvent effects described by Spallanzani, it clotted milk. The acid of the gastric secretion is described by these workers as hydrochloric, and they claim to have obtained evidence, in some cases, of the presence of acetic and

even nitric acid, which, if substantiated by further inquiry, is of curious interest, as these two acids have never been reported in the normal gastric juice of mammals. These observers noted that the strength and amount of the secreted acid depended on the nature of the food material ingested. Irritating substances, such as pepper, brought forth the largest amount of acid, and the gastric juice secreted after a diet of meat reacted more strongly acid to litmus than the secretion following the use of liquid food and sugar.

Wilczewski⁴¹, in 1870, at Heidenhain's institute, performed some experiments with the pepsin of the pigeon's stomach. Extracts of the mucous membrane were made with 0.2 per cent HCl, and the digestion of egg albumin in these fluids was tested. A control trial was carried out with 0.2 per cent HCl alone and more albumin was dissolved by this solution than in the extract which presumably contained the peptic enzyme. Obviously, some error was involved in the performance of these experiments.

In 1890 Klug³⁵ published a communication dealing with the digestion processes in geese. He was unable to demonstrate an acid peptic secretion in the crop or esophagus. Traces, which might have regurgitated from either the fore stomach or gizzard, were sometimes found in these localities. Extracts of the latter organ, made with 0.2 per cent HCl, readily dissolved proteid substances.

On the authority of Teichmann,³⁴ the glands in the proventriculus were found to be of compound tubular structure and resembled mammalian gastric glands. The secreting portion of the gland is described as containing but one variety of cell elaborating both pepsin and hydrochloric acid; in mammals the acid is probably secreted by a type of cell distinct from that producing the enzyme.

The muscular stomach or gizzard presents a peculiar structure. On a more or less strongly developed muscular foundation is found a layer of tubular glands which manufacture a secretion, the character of which has not been determined. The topmost layer of the mucous membrane is made up of a horn-like mass of stratified squamous epithelium. A complete list of the literature bearing on the histology of the gastric apparatus of the bird, published prior to 1896, is given by Oppel.^a

The most recent and extensive contribution to the literature on the digestive processes in birds was published by Paira-Mall⁴² in 1900. The main conclusions of this paper may be stated as follows: In granivorous birds the gland cells of the mucous membrane of the proventriculus are laden with peptic enzyme or zymogen in the fasting period. The ferment appears to be stored up in the form of granules, which are discharged from the cells rather quickly during digestion, so that

^a *Lehrbuch der vergl. mikrosk. Anatomie der Wirbelthiere, Erster Theil: Der Magen*, s. 150 ff., Jena, 1896.

the mucous membrane contains much less ferment during the first few hours of this process than in the fasting period. As has been established for mammals, the zymogen develops into the full-fledged enzyme by the action of the free hydrochloric acid secreted by the gland cells. The mucous membrane seems to yield the minimum amount of ferment six to eight hours after the ingestion of the meal, simultaneously with the height of digestive activity. At the tenth to eleventh hour after taking food, the quantity of enzyme commences to gradually increase.

The "muscular stomach" or gizzard secretes no pepsin, and the evidences of the enzyme found in this organ are to be attributed to the secretion of the proventriculus. As reported by Klug and Teichmann, no peptic secretion could be demonstrated in the crop or esophagus. Mucus and in some instances "crop milk" were the only secretions noted. Gastric digestion in birds possessing a so-called middle stomach—as the crow, magpie, etc.—was investigated and results were obtained corresponding to those noted in the granivorous birds.

THE PANCREATIC JUICE.

There is but scant literature bearing on pancreatic digestion in birds available. Claude Bernard,⁴³ in 1856, first pointed out the great vital significance of the pancreas in birds. He removed the organ and observed that, while the subjects endured the operation well, starch passed through the gastro-intestinal tract undigested and death resulted in from ten to twelve days. It is of interest in this connection to note that the total removal of the pancreas in mammals leads to the production of a fatal diabetes. Whether this effect ensues in birds under like conditions can only be answered by experimental inquiry. This factor, however, may have been operative in the fatal results induced by Bernard's experiments.

The effect of ligature of the pancreatic ducts in pigeons has been studied by Langendorff.⁴⁴ The gland in this class of birds possesses from two to four ducts. The results obtained were essentially the same as those reported by Bernard after total removal of the organ. The animals suffered from severe hunger and survived but a few days. The carbohydrate component of the diet was practically unassimilated; the proteid and fat but slightly. It was noted, as would be reasonably anticipated, that the life of the pigeon could be considerably prolonged by administering large amounts of soluble sugar.

Langendorff carried out observations on the digestive enzymes of the pancreatic juice. The ferments were not separated, but he reports that the starch and fat-digesting power of the secretion were relatively more active than the proteolytic. Klug³⁵ extracted the pancreatic enzymes of the goose and states that proteid and starch were readily digested; the fat-splitting enzyme appeared to be present in a relatively

very small amount; but the presence of a rennet or milk-curdling enzyme could not be demonstrated.

It may be well at this place to point out that the pancreas of the bird is very large in relation to body weight as compared with that of the mammal. In the rabbit the weight of this organ is about one six-hundredth of the body weight, while Langendorff has estimated that in the pigeon this gland is from an eighty-second to a hundred and twenty-fifth of the total weight.

Pancreatic digestion was investigated by Paira-Mall⁴⁶ in both granivorous birds and those possessing the "middle stomach." The histological changes associated with the elaboration and discharge of ferment in the pancreas were very similar to those described by Heidenhain⁴⁵ in the dog under like circumstances. The gland cells in the fasting period contained little proteolytic and amylolytic ferment, but simultaneously with the onset of gastric digestion the cells became crowded with the zymogen granules. Paira-Mall makes no reference to the presence of a rennet-like enzyme in either the stomach or pancreas, and no attempt was made to demonstrate the existence of enzymes in the intestinal wall.

This brief review of the literature indicates that there is an urgent need for investigation of the digestion processes in birds. This is not only of scientific interest from the standpoint of comparative physiology, but of practical significance as an aid in the interpretation of the data of digestion experiments. The detailed chemical changes brought about by the ferments upon the different classes of food-stuffs, and hence the determination of the final products of digestive activity, are yet to be investigated. A more exact study of the distribution of the enzymes in the gastro-intestinal tract and the effects of varying conditions upon their activity furnish promising objects of investigation.

REVIEW OF THE LITERATURE ON THE DIGESTIBILITY OF POULTRY FOODSTUFFS.

The earliest publication⁴⁶ bearing on the digestion coefficients of the nutrients of feeding stuffs for poultry appeared in 1843. The digestion of barley in a cock and hen were studied, chalk and sand being offered with the grain. The chickens excreted a little less than one-half of what they consumed, and the excrement consisted of, approximately, 25 per cent of inorganic matter.

Voit,⁴⁷ in 1861-62, determined the nitrogen balance in a dove, employing a period of observation of one hundred and twenty-five days. This experiment, while not a digestion test, is worthy of mention in this connection, as it demonstrated the absence of a respiratory exchange of nitrogen.

Weiske and Mehlis,⁴⁸ in 1877, investigated the digestibility of crude

fiber in hens. The food consisted of the leaves of the dandelion and stalks of the horsetail rush. They came to the conclusion that crude fiber was not assimilated.

Observations on the digestibility of millet in hens were reported by Kalugin⁴⁹ in 1897. He asserted that the addition of sand or charcoal to the food increased the digestibility of the nutritive ingredients, especially in the case of crude fiber and crude protein. The percentages of increase in absorption of these nutrients for two experiments were in one subject 4.58 and 2.33 and in another 7.73 and 7.89, respectively.

In another publication⁵⁰ he records data with reference to the digestibility of peas, buckwheat, wheat, and barley in hens. The following conclusions were drawn: Hens digest the crude proteid of peas and barley in about the same proportions as has been observed in experiments with other farm animals; the assimilation of the crude proteid of wheat and buckwheat was much inferior to that found in the other two grains. In their capacity to utilize fat, fowls in some respects resemble swine and in other respects, herbivora.

Grost investigated the individual digestibility of oats, barley, and rye at the Peterhof experimental farm in 1900. The experiments were performed under the direction of von Knieriem.⁵¹ In the experimental period proper 70 grams of the grain in use were fed once daily. The most noticeable feature of the experiments was the low availability of the fat of rye as compared with oats and barley. This finding was in harmony with results obtained in digestion experiments with rye carried out with pigs, cows, and sheep. The digestion coefficient of fat in oats was considerably higher than in the case of barley. Crude proteid was found to be digested in higher proportion in rye and barley than in oats. The crude fiber of barley and oats was absorbed to a slight extent; considerably more of this constituent was assimilated in the case of rye.

In Bulletin No. 46 of the Oklahoma experiment station Fields and Ford⁵² record experiments designed to study in poultry the digestibility of Kafir corn, Indian corn, and cowpeas. Certain features of the conduct of these experiments are open to criticism and will be discussed later (see p. 61). The deductions drawn from the tests were as follows: The digestion coefficients of Kafir corn and Indian corn are rather higher when the grain is fed whole than after its ingestion in the form of meal. The reverse of this was the case with cowpeas, although the differences were not marked. The percentage of digested crude proteid, ether extract, and nitrogen-free extract was generally higher in both Kafir and Indian corn than in cowpeas.

Lehmann⁵³ recently performed two digestion experiments with hens, wheat and peas being the grains studied. The outlets of the urine and feces were separated by means of an artificial anus established in the

abdominal wall. The practical value of the data obtained in experiments where such an operative procedure is employed may be somewhat questioned, owing to the possibility that the digestive processes may be abnormally influenced. The general results of the experiments were as follows: The assimilation of the crude fat of wheat was much less than was observed in the case of peas. On the other hand, the digestion coefficient for crude proteid in peas was considerably the greater. The reverse relation held true for the nitrogen-free extract. Lehmann concluded that the digestion coefficients for poultry are more comparable to those of swine than to those of other farm animals.

Shortly before the completion of the writers' experiments a publication on this subject appeared from the Berlin Hochschule. The experiments were performed by Paraschtschuk⁵⁴ and deal with the digestibility of corn in hens and cocks. As in Lehmann's experiments, an artificial anus was established in order that the urine and feces might be separately collected. He reports that the only untoward sequence of the operation was a condition of constipation, which necessitated frequent flushing of the intestines with physiological salt solution in order to effect defecation. The normal condition of the feces, however, was soon restored. The inferences drawn from these experiments are as follows: The digestive capacity of poultry does not depart widely from that of the large farm animals. In their ability to assimilate crude fiber they resemble swine more than ruminants and horses. The digestion coefficient for ether extract corresponds most closely to that of ruminants. Poultry assimilate nitrogen-free extract in less degree than any of the other three classes of animals.

The digestion coefficients comprised in the five papers just referred to are presented in Table IX on page 99, the digestibility of corn, oats, wheat, barley, peas, rye, and buckwheat having been considered. Data on three grains only—corn, peas, and barley—have been reported by more than one experimenter. A casual comparison of these data shows that, with the exception of the digestion coefficients of barley, the results of the different experiments are more or less lacking in agreement. These discrepancies may be accounted for in various ways, as differences in analytical methods, in the length of experimental periods, and in the manner of collection and preservation of the excrement. The factor of idiosyncrasy might also act as a cause of variation. A more detailed consideration of these data will be given at another place in connection with the discussion of the results of the writer's experiments.

MEAT AS A SOLE DIET FOR POULTRY.

Experiments planned to study the digestibility of meat have not as yet been undertaken with poultry. Meissner,⁵ Minkowski,¹⁷ Meyer.⁵⁵

and Kionka⁶⁶ have fed meat to birds experimentally, but not with a view to the determination of digestion coefficients. Meyer and Kionka investigated the nitrogenous metabolism after meat feeding. Kionka confirmed an observation of the other investigators named in finding the uric acid output enormously increased after a heavy meat diet. He found a rise of 550 per cent over that excreted following an exclusive diet of barley. The excrement from meat feeding showed an enormous content of water as compared with the grain excrement.

It is of interest in this connection to refer to a pathological condition noted by Kionka as a result of this exclusive meat feeding. Each subject received large quantities of beef (150 grams daily) over varying periods of many weeks in length, and was kept in close confinement. This diet was responsible for the production of symptoms simulating in a striking manner the condition of gout in man. The autopsies revealed deposits of uric acid in certain of the joints and tissues. These results are of special interest when associated with the fact that the addition of meat to an ordinary diet occasions a pronounced increase in the elimination of uric acid in man. This effect may be attributed to the content of purin bases in this form of diet, and this fact may bear a causal relation to the results noted above in hens. The findings of these experiments are instructive as suggesting the possible injurious effects of feeding meat to poultry, either exclusively or in an unduly large proportion in a mixed ration. The tendency to harmful results in the above experiments would no doubt have been greatly lessened if the animals had been given unlimited opportunity for exercise in the open air.

Kionka also studied the influence of the feeding of lime on the nitrogenous metabolism. The animals consumed 150 grams of meat daily, to which were added 10 grams of egg shells—which consist largely of calcium carbonate. The results were strikingly significant. The water of the excrement was enormously increased, while the dry matter remained practically unchanged. On the other hand, while the total output of nitrogen showed little change, the uric acid excretion was reduced nearly one-half as compared with the results on the same diet without the inclusion of lime. This fall in the uric acid output tends to indicate a decrease in the assimilation of proteid, a suggestion which the microscopic examination of the excrement confirmed. In other words, the addition of large amounts of lime to the food would seem to depress the digestibility of proteid matter. While this statement may not be taken as conclusive, it suggests the possible harmful effects of feeding lime to poultry in undue proportion.

THE GLYCOGEN FORMATION IN BIRDS.

Closely associated with the digestibility of foodstuffs in poultry is the question of the glycogenic function of the liver. While the main

features of the process are probably identical in both birds and mammals, there may be minor differences of significance. It seems desirable to briefly mention the few observations recorded on the subject.

Tscherinow⁵⁷ first investigated the conditions of glycogen formation in birds in 1869. He observed that the glycogen disappeared very rapidly from the liver of fowls deprived of food, and the organ became practically glycogen-free in three to four days. Prausnitz⁵⁸ in 1890 investigated the question and came to the following conclusions: A starvation period of four days sufficed to render the liver free from any appreciable quantity of glycogen. Following the administering of cane sugar, the liver glycogen rose rapidly, reaching its maximum from the twelfth to the twenty-fourth hour. The value then fell rapidly, and at the thirty-sixth hour the liver was again practically glycogen-free. When the liver had attained a certain content of glycogen certain of the other organs and tissues of the body commenced to show an increased accumulation of this carbohydrate. This fraction of the body-glycogen increase was considerably greater after the eighth hour than that observed in the liver, and the maximum was reached at about the twentieth hour. The body-glycogen fell rapidly at first but later more slowly, and the minimum was reached at about the forty-eighth hour.

Hergenhahn⁵⁹ has also investigated several questions connected with the course of the formation of glycogen in the liver and muscles. Six-day starvation periods were imposed on the animals to render the liver glycogen-free. In three series of experiments the influence of 10, 20, and 30 grams of saccharose, respectively, on the glycogen formation in both liver and muscle was considered. The liver glycogen rose rapidly after the administration of the sugar, but the increase of the glycogen in the muscles was very gradual, appearing from twelve to sixteen hours later. It was noted that the liver glycogen practically equaled the content in the muscles in the sixth hour following the meal. The maximum of muscle glycogen appeared to be practically independent of the quantity of sugar ingested, and appeared in from twenty to twenty-four hours. Among many other observations it was reported that the smaller the quantity of sugar fed the more rapidly was the level of glycogen production in the liver reached.

ROUTINE AND METHODS OF PRESENT EXPERIMENTS.

The general plan of the experiments of this investigation is indicated in Table I (see p. 89). Nine hens (A, B, C, D, E, F, H, M, and N) and one cock (G) were employed as subjects and sixteen digestion trials were made. Additional experiments with other animals were also undertaken, but owing to derangement of digestion or other abnormal conditions arising these were abandoned. Chickens of varying weight were selected and were kept under observation for

not less than two weeks before any digestion tests were begun. During this time they were carefully watched in order to ascertain whether normal conditions prevailed. The digestion experiment proper was preceded by a preliminary period during which the experimental diet was fed. This preliminary period was never shorter than five days and served the following ends: (1) To accustom the fowls to the experimental diet; (2) to obtain data relative to the average daily voluntary consumption of the diet; (3) to eliminate from the alimentary canal residues from previous feeding.

During the preliminary period of the experiments the fowls were fed *ad libitum*, and so allowed to fix their own daily consumption of food. In the greater number of the experiments the daily ration offered during the digestion period corresponded to the average daily requirement observed in the preliminary period. In a few cases they received a quantity somewhat less than this in order that entire and absolutely uniform consumption of the ration might be secured. It was thought, however, that the conditions would conform more closely to those obtaining on the farm if the fowls were fed sufficient grain to entirely satisfy the daily appetite, even at the expense of some irregularity of food ingestion. It was also deemed unwise to extend the preliminary period over a longer time than was necessary for the objects above considered, as the more prolonged the use of a single article of food the greater the tendency to loss of appetite due to its monotony. The digestion periods proper of the experiments varied from six to thirteen days.

In the case of the meat experiments it was particularly needful to insure the entire and immediate ingestion of the meat fed. Unconsumed meat in the cage pan would soon tend to decompose, and owing to the large loss of water difficulty would be met with in accurately weighing any portions left over from the day's ration.

A common source of error in digestion experiments is involved in the irregular ingestion of food and excretion of feces. The periods of the present experiments seem of sufficient length to counterbalance the effect of such fluctuations. It has already been pointed out that the experimental conditions imposed on the animals tend to lead to depressing effects, and particularly in the case of subjects of so active a temperament as poultry. For this reason it is desirable that digestion trials should be performed with animals which have not been subjected to a longer confinement than is absolutely required.

The chickens for the experiments were kept in wire-netting cages 29 inches long, 17 inches wide, and 23 inches in height. The bottom of each cage was fitted with a galvanized iron tray, which could be easily removed and cleaned. The grain was offered in feeding boxes constructed of tinned iron fastened at the sides of the cages. These boxes were provided with a sloping bottom designed to allow the food

to slide to a lip which projected into the cage and was of such size as to permit of the fowls feeding without scattering the grain to any great extent. As a further precaution against loss of food cloth was fastened around the lower interior part of the cage. This arrangement prevented a loss of grain through the wire meshes of the cage and confined in the cage tray all of the food not immediately consumed. Feeding boxes of similar construction to the above were also employed for sand.

MANAGEMENT OF THE CHICKENS.

The chickens were carefully weighed each day in both the preliminary and digestion periods. This observation was made immediately after the removal of the collection pan and just before the feeding of the morning ration. The afternoon meal was given concurrently with the removal of the collection pan. The condition of the fresh excrement was carefully watched both morning and afternoon, its odor, consistency, and general appearance being noted. The appearance of the comb, condition of the appetite, relative loss of feathers, general bodily tone, etc., were given constant attention as possibly affording evidences of malnutrition. At any indication of a deviation from normal conditions the experiment was promptly abandoned.

The grain selected for the experiments was repeatedly winnowed and then carefully examined by hand in order that a lot as clean and uniform as possible could be employed. After sampling for analysis the grain was stored in air-tight cans and a little chloroform added to exclude any formation of molds. The preparation and sampling of the beef fed is described on pages 29 and 30. Feeding was always conducted at exactly the same time each day in each experiment. In some instances the chickens were fed once a day—in the morning—in others both in the morning and late afternoon. At the end of the daily period the grain remaining over was carefully collected and weighed. Water was supplied in circular glass dishes about an inch in depth, which were firmly fastened to the sides of the cages. The balance left over from each day's quota was measured, and the loss by evaporation checked by observing the change in volume in a control dish placed outside of the cage for a comparable period of time.

Gravel was offered in many of the experiments, and in such cases was given *ad libitum*. It was prepared in the following manner: Quartz rock was crushed in an iron mortar and the material passed through sieves with meshes of varying size until a quantity was obtained, the individual particles of which were fairly uniform, measuring roughly one-eighth of an inch in diameter. This mass of material was repeatedly treated with boiling dilute hydrochloric acid to remove any admixed traces of iron derived from the mortar or other soluble inorganic matter. The sand was widely scattered by the

animals on the trays of the cages, and much care was necessary to recover the same. The daily consumption was not determined, but the total ingestion for the experimental period was observed in several instances.

The advisability of supplying the chickens with marble was considered. Much difficulty lies in the way of an accurate determination of the consumption of gravel and marble when both of these materials are placed at the disposal of the animals. They become scattered together upon the bottom of the cage, and it is very difficult to distinguish accurately between the marble and quartz particles. In a few cases, as will be indicated later, a mixture of sand and marble was fed, but no account was taken of the amount of each consumed.

THE APPARATUS FOR COLLECTION OF THE EXCREMENT.

Methods of collecting the excrement adopted by certain observers are open to much criticism. Thus, Grost⁵¹ placed the subjects in a box-like structure which necessitated a stationary position throughout the period of the experiment. Kalugin⁴⁹ employed a similar method. Such close confinement of animals of so pronounced a vitality seems abnormal, and rather liable to lead to results deviating from the physiological. In the experiments of Fields and Ford⁵² the fowls were allowed considerable exercise, but the excrement was allowed to drop upon the tray of the cage and to a certain extent dry there before removal. Under these circumstances there is opportunity for a considerable loss of ammonia and progressive decomposition of the excrementitious matter. Paraschtschuk⁵³ used an ingenious method in the collection of urine and feces from his animals, upon which the operation for artificial anus had been performed. A small rubber bag was fastened about the artificial anus to receive the feces. This was inclosed by a larger rubber bag fitted about the rear portion of the animal, to serve as a receptacle for the urine.

After considerable study, the writer adopted the following method of collecting the excrement as the most feasible for the grain experiments. A device, made of aluminum and somewhat resembling a bed-pan in shape, was constructed. It was arranged to fit the rear portion of the fowl, and was provided with an opening which could be fitted tightly about the cloaca. This collection pan was fastened to the chicken by strips of aluminum, which were riveted to the sides of the upper third of the pan and met by their free ends in front of the wings, where they were securely fastened together by means of stout cloth tape. This arrangement was reenforced by strips of cloth tape, passing from lugs attached to the upper part of the pan and tied together in front of the wings. Plates I to IV show the collection pan and its appearance when adjusted.

The fowls evinced violent irritation after the attachment of the collection pan. The appetite was greatly reduced, little excrement was passed, and a partial loss of equilibrium ensued. Several days usually elapsed before normal conditions were restored, and the fowl ceased to show a disposition to remove the device. Even after the fowls had become thoroughly habituated to its employment, some irritation was usually shown during the attachment and removal of the apparatus. The pan was fastened to the chicken in the preliminary period of the experiment in order that it might become accustomed to its use before the beginning of the digestion trial.

The digestion experiments with meat were carried out after the completion of the grain experiments and it was soon recognized that a modification of the collection apparatus would be necessary. The excrement from exclusive meat feeding contains a large amount of water in contrast with that from grain food. The watery portion filled up the small spaces between the overlapping edges of the aluminum pan, depositing quite large amounts of urate which could not be quantitatively removed from these places. It did not seem feasible to swab out the apparatus with dilute sodium hydroxide, as considerable ammonia might be lost. The advisability of employing rubber-covered cloth bags was considered and they were found to fulfill the purpose quite satisfactorily. Draw-string bags were made provided with small loops about the margin, to which cloth tape was tied in strips. The strings were passed over, at the sides, and under the body, meeting in front of the wings. A decided advantage of this arrangement was the freedom of the animals from irritation. The material proved to be impervious to water, held its position well when carefully applied, and allowed of easy transfer of the excrement.

METHOD OF PRESERVATION OF THE EXCREMENT.

In the first five experiments the collection pan was removed once daily, in the remaining tests it was detached both morning and afternoon. The removal in the morning was carried out at the same time each day in order that the exact weight of the excrement for the twenty-four hours might be ascertained. This double removal of the excrement during the day was carried out to prevent, as far as possible, fermentation, with a loss of ammonia. Repeated tests always indicated that traces of free ammonia could be detected in the freshly excreted material. To arrest this fermentative process and consequent loss of ammonia, the excrement was transferred as quickly as possible from the collection pan to a casserole and stirred under 95 per cent alcohol. The excrement was dried by evaporation of the alcohol on the steam bath, the alcohol being renewed if required. Poda⁶⁰ reports excellent results from the application of this method to human feces. In order to prevent the volatilization of any free ammonia which might be

present, it was necessary to acidify slightly the alcohol. Hydrochloric acid was found unsatisfactory, owing to its charring action, but acetic acid fulfilled the requirement perfectly. The excess was readily driven off with the boiling alcohol, care having been taken at the beginning to add a minimal quantity of the acid. The samples were readily dried in this manner in one to two hours. Vigorous and persistent scraping was required to effect a satisfactory transfer from the collection pan, and while a slight amount of aluminum was undoubtedly also removed, it is of no significance, as the digestion coefficient for inorganic matter can not be estimated in the present experiments (see p. 8.)

At the close of the experimental period proper, after thorough scraping, the aluminum pans were washed quantitatively with a 1 per cent solution of sodium hydroxide in order to remove any slight traces of uric acid adhering thereto. A slight loss of ammonia ensued, but in all probability is within the limits of error. The amount of uric acid thus obtained was quantitatively determined and the result added to that observed for the excrement for the total period. After the completion of the drying process, the daily sample of excrement was transferred from the casserole to a weighed glass-stoppered bottle, a few drops of chloroform being added as a precaution against the formation of molds.

THE METHODS OF ANALYSIS ADOPTED.

The methods of analysis followed in this investigation may be considered under the following heads; (1) Preparation and sampling of the food and excrement; (2) Organic matter; (3) Crude proteid; (4) Metabolic nitrogen; (5) Uric acid; (6) Ether extract; (7) Ammonia; (8) Crude fiber; (9) Pentosans; (10) Nitrogen-free extract; (11) Soluble ash and silica.

PREPARATION AND SAMPLING OF THE FOOD AND EXCREMENT.

The grain designed for feeding—oats, corn, or wheat—after being thoroughly cleaned as described on page 26, was widely spread out in a thin layer from which various portions were selected. This process was repeated with the grain so selected until a sample of about 400 grams was obtained. This material was ground to a fine powder and a representative sample of about 50 grams was selected for analysis.

The handling of meat in metabolism experiments, is much more difficult than is the case with grain. W. J. Gies⁴¹ has proposed an improved method for preparing and preserving meat for such experiments, and the writer has followed the procedure with very satisfactory results. A quantity of beef sufficing for the digestion experiments planned was washed with cold water and freed as far as possible from all extraneous fat and connective tissue. Especial care was exercised

to prevent contamination with any foreign material. The beef was then passed twice through a sausage machine and was afterwards chopped as finely as possible. It was then rolled up into balls of convenient size, inclosed in cheese cloth, and subjected to gradually increasing pressure in a large meat press. After three to four hours the meat seemed to be exhausted of liquid as far as practicable; it was then thoroughly kneaded and spread out in a thin layer. As quickly as possible three samples were taken for the determination of moisture. These samples were made up of small portions selected from various parts of the material and placed in tightly stoppered, weighed glass bottles. Portions for analysis were similarly taken and placed under alcohol. The remaining meat was rapidly rolled up into balls, weighing 25 grams each, incased in waxed paper, and placed in a large glass jar. This was surrounded by a freezing mixture in the refrigerator, and the meat was thus kept frozen and perfectly fresh throughout the period of the experiment. On removing the meat from the jar and wrapper no evidence of separated fluid was seen in any case.

The meat sample selected for analysis was thoroughly ground under alcohol in a mortar. It was subsequently transferred to a convenient receptacle and heated over the steam bath to expel the alcohol, which was once renewed to insure the greatest possible drying of the meat. The material was then ground in a mill and readily reduced to a powder, which furnished a very satisfactory sample for analysis.

Especial care was required in preparing the excrement samples, from both the grain and meat, owing to the heterogeneous character of the material. The large proportions of silica and crude fiber present in the grain excrement rendered the selection of representative samples particularly difficult. The uric acid, as indicated by little white areas, is ordinarily scattered very irregularly throughout the feces. The air-dried samples were repeatedly ground until they were as finely divided as possible. Extreme precautions were taken against loss of material in this process. Much time and labor were required in the case of the samples of oats excrement, owing to the very large amount of fiber present. The whole of the excrement procured from one experimental period was ground and sampled for analysis. The samples in the case of both the food and excrement were preserved in well-stoppered, weighed glass bottles, and the moisture content determined at frequent intervals when analytical operations were in progress. In the selection of portions for analysis, care was observed to shake the main sample thoroughly and to select small quantities from different parts of the material. As the sand and fiber tend to settle toward the bottom, it was thought that in this way a sample as representative as possible would be obtained. In the analysis of the grain excrement samples weighing from 2 to 3 grams were employed, for it seemed unwise to use smaller quantities in view of the hetero-

geneous character of the excrement. In the case of meat excrement smaller samples could be employed, owing to the smaller ash and higher uric acid content.

Moisture was determined in all samples by drying in a Carr's⁶² vacuum oven at 60° C. with a vacuum of 22 to 27 inches. It was noted that the excrement tended to hold the last traces of moisture very tenaciously and readily took up water again, thus necessitating rapid weighing.

ORGANIC MATTER.

For reasons which have been previously presented, the digestion coefficient for inorganic matter in poultry can not be estimated without a previous operative procedure to separate the outlet of urine and feces. As a result of this fact the percentage of assimilated dry matter fails of estimation. The digestion coefficient for organic matter, however, is capable of indirect determination. Obviously, the excrement comprises more than the metabolic and the undigested organic matter of the food; it also includes the urinary organic matter. Hence the latter quantity must be deducted if the amount of organic matter in the feces is to be ascertained. The organic matter of the excrement corresponds to the total solids minus the sum of the water, inorganic matter, and ammonia. The great bulk of the organic matter of the urine is represented by uric acid, and the deduction of the quantity of this body from the organic matter of the excrement yields the approximate amount of organic matter in the feces.

It is recognized that there are two slight sources of error involved in this calculation: First, the fecal material contains metabolic organic substances in the form of bile acids and pigments traceable to the bile, mucous, and epithelial débris from the walls of the gastrointestinal tract, traces of the gastric, pancreatic, and intestinal juices, indol and skatol from intestinal putrefaction, etc.; second, the urinary fraction of the excremental organic matter contains, besides uric acid, traces of organic substances, as urea, purin bases, etc. The error involved in these two connections is probably very slight and of little or no practical significance. The actual digestion coefficients, however, are somewhat higher than represented in the tables of these experiments.

CRUDE PROTEID.

The various methods for the estimation of proteid matter in food-stuffs were considered, but serious difficulties were encountered in the application of any of them to the excrement. The methods of direct determination presuppose either that the proteid of the material in question is soluble in water or that treatment with hot water under certain conditions of precipitation will remove the nonproteid nitrogenous matter. Little or no information, however, is at hand with

reference to the chemistry of the proteids of the excrement following the feeding of corn, oats, wheat, or beef, and we possess no definite information as to the details of the changes undergone by these proteids in their passage through the gastro-intestinal tract of the fowl.

It should be kept in mind that a certain fraction of the excrement proteid may be in the form of zein, and hence insoluble in both cold and warm water. Furthermore, any water-soluble proteid may have been rendered insoluble by coagulation in the drying process over the steam bath. Again, a considerable fraction of the nonproteid excrement nitrogen may be dissolved in the form of uric acid on extraction with hot or cold water and, although dilute alkalies will completely remove uric acid from the excrement, proteid matter is liable to be also involved in the solution. The method of Stutzer⁶³ directs that the material to be analyzed be extracted with hot water to bring all soluble proteid matter into solution. It will be remembered that this proteid so dissolved is precipitated by copper sulphate; the original residue together with the precipitate is thoroughly washed with hot water to remove amid bodies. In Mallet's⁶⁴ method the proteid is assumed to be wholly dissolved by warm water.

Several investigators have estimated the crude proteid of the feces of farm animals by digestion with pepsin and 0.2 per cent HCl. The nitrogen rendered soluble by such treatment has been assumed to represent the crude proteid. In applying this digestion method to the excrement the writer has observed that not only does a fraction of the uric acid enter solution, but the total ammonia is necessarily dissolved by the hydrochloric acid. Hence control determinations would be required on the amount of solution of these substances. The control tests must be performed with 0.2 per cent HCl alone, and we have no certainty that this reagent may not have a solvent action on the crude proteid of the excrement. Furthermore, the estimation of uric acid in the 0.2 per cent HCl extract of the excrement is not practicable owing to the large admixture of pigment. As will be pointed out later, absolute alcohol has proved a fairly satisfactory solvent for the removal of the coloring matter of the excrement. However, Chittenden and Osborn⁶⁵ have shown that certain grain proteids—namely, the zeins—are soluble in dilute alcohol, and we have observed that absolute alcohol removes a proteid-reacting substance or substances from the corn and the oat grain. Hence removal of coloring matter from the excrement by absolute alcohol may involve a loss of proteid matter as well.

The application of the digestion method to the excrement of poultry does not seem feasible unless a separation of the urine and feces has been effected. Paraschtschuk⁶⁶ has studied the matter under these circumstances and his results will receive detailed consideration later



THE COLLECTION PAN, ATTACHED—SIDE VIEW.



THE COLLECTION PAN, WITH FASTENINGS—SIDE VIEW.

on in this paper (see pp. 59, 60). It was decided in view of the above considerations to determine proteid matter indirectly.

The nitrogen compounds of the excrement may be classified in four groups: (1) Ammonia, (2) uric acid, (3) crude proteid, and (4) metabolic substances of the feces and bodies in the urine exclusive of ammonia and uric acid.

In the present experiments the data for the nitrogen of the total excrement on the one hand, and uric acid and ammonia on the other, have formed the basis for the calculation of the nitrogen of the crude proteid. Total nitrogen was determined by the Gunning modification of the Kjeldahl method. The methods for the estimation of uric acid and ammonia will be described later. The sum of the uric acid and ammonia nitrogen was deducted from the total nitrogen and the result multiplied by the usual factor for crude proteid—6.25. It is fully recognized that the use of this factor is not wholly satisfactory. Distinctive factors have been recommended for different grains, based on the chemical composition of the proteids in these materials. However, the question of the factor employed would not affect the accuracy of the digestion coefficient, provided the proteid of the feces has the same percentage of nitrogen as the digested proteid matter. On this point we have at present no positive data. The different individual proteids of the same grain may show a varying digestibility, and thus the same factor may not apply to both food and feces.

The crude proteid of the grain was calculated in the customary manner by estimation of the total nitrogen and multiplying this result by the same factor as employed for the excrement. It has been pointed out by several workers that all of the nitrogen of corn, oats, or wheat is not present in the form of proteid matter. Thus a fraction of the nitrogen in some grains may appear as amido acid or amines; Richardson and Crampton,⁶⁶ in 1885, isolated allantoin from wheat germs; Frankfurt⁶⁷ also was able to demonstrate the presence of asparagin in the same material; Frankfurt and Schulze⁶⁸ observed that wheat germs and sprouting barley contained betain and cholin—bodies belonging to the class of amines. It is clear that the presence of such substances must involve an error in the analysis for crude proteid; on the other hand, such an error tends to counterbalance that incurred by the presence of metabolic nitrogen in the feces.

METABOLIC AND "RESIDUAL" NITROGEN.

In the calculation of crude proteid in the excrement we have left out of consideration that fraction of the excrement nitrogen included above under (4) in the grouping of the nitrogen compounds. The correction for metabolic nitrogen in ruminants, horses, and hogs may make the digestion coefficient considerably higher. Thus Bartlett and Merrill,⁶⁹ and Jordan and Merrill⁷⁰ determined the digestion coefficients

for crude proteid of 15 food materials in sheep. On applying the correction for metabolic nitrogen, the average increase in the value of the digestion coefficients was 10 to 11 per cent. Bartlett⁷¹ fed timothy hay, corn, and skim milk to sheep, and by the application of certain solvents he claimed that 30 to 45.5 per cent of the total nitrogen was extracted in a presumably nonproteid form. Patterson⁷² estimated the digestion coefficient for crude proteid in steers using rations of corn stover, silage, and grain. When the metabolic nitrogen was taken into account the percentage of assimilation was raised 9 per cent.

Obviously it is thus highly desirable that the metabolic nitrogen of poultry excrement be determined from the point of analogy with ruminants, horses, and hogs. The admixture of the urine with the feces, as previously pointed out, greatly complicates the matter and involves more serious difficulties than are met with in the other classes of farm animals.

Attention must also be paid to the urinary nitrogen in forms other than uric acid and ammonia. This is present as urea, purin bases, and probably other unknown bodies. It is apparent that the solution of this question would be greatly simplified if the urine and feces were separated by means of an artificial anus.

The accuracy of many of the methods designed for the quantitative analysis of metabolic nitrogen in the feces is not yet demonstrated. Ether, hot alcohol, hot water, and cold limewater have been employed as solvents. As we have already pointed out, the hot alcohol may extract proteid matter of the class of zeins. The use of limewater is open to some criticism, as this reagent dissolves mucin—a gluco-proteid. The procedure of subjecting the feces to digestion with 0.2 per cent HCl and pepsin has been utilized, the undissolved nitrogen being regarded as that fraction of the fecal nitrogen in the metabolic form. This method has been used by both German and American investigators and in many cases has yielded results comparing favorably with those secured by successive extractions with the several solvents referred to above. A criticism of this plan lies in the possibility of the solution of nitrogen material other than proteid.

The use of hot water and limewater is precluded in the case of poultry excrement, owing to the presence of uric acid, and for the same reason the pepsin-digestion method does not appear applicable. In several samples we have estimated the nitrogen dissolved, respectively, by ether, 95 per cent alcohol, absolute alcohol, and acetic ether. These data are presented in Table VIII and are discussed on pages 57 and 58.

URIC ACID.

It may be appropriate to consider briefly some of the more important properties of uric acid before considering the analytical methods for the determination of the same in poultry excrement. Uric acid is

a member of the class of bodies known as the diureides, in which the residues of two urea molecules are united to a carbon-containing nucleus. Thus uric acid was synthetically prepared by Horbaczewski on heating urea with trichlorolactamid, and it is of interest in this connection that Minkowski⁹ found that the uric acid in the urine of the goose deprived of the circulation through the liver could be largely replaced by ammonium lactate. (See p. 12.)

Pure uric acid forms a white powder and presents crystals of small rhombic form of more or less prismatic or tabular type. It is very difficultly soluble in cold water—1 part to 15,000; it is less insoluble in boiling water—that is, 1 part in 2,000. Pure uric acid is not dissolved by ether or alcohol. It was formerly regarded as being rather less insoluble in dilute mineral acids than in water, but more recent investigations⁷³ throw some doubt on the matter. Concentrated sulphuric acid dissolves uric acid without decomposition and on freezing the solution a crystalline sulphate separates out. It is readily dissolved by the hydroxides and carbonates of the alkali metals and by the organic basic bodies, piperidine and piperizine.

Uric acid has many of the properties of a dibasic acid. It forms three classes of salts. If uric acid be dissolved in a solution of sodium carbonate an acid urate is obtained, which compound is soluble with difficulty in water. On dissolving in sodium hydroxide a second hydrogen atom is replaced and the neutral urate ($C_5H_2Na_2N_4O_3$) results, which is readily soluble in water. The uric acid salts of the heavy metals are practically insoluble. The third order of salts—the quadriurates—are of special physiological interest. They may be prepared by boiling uric acid with dilute solutions of acetate of potassium, and from such a solution the quadriurate separates either in an amorphous or crystalline condition. As the quadriurates are so readily broken up into acid urates and uric acid on treatment with water, their solubility in this menstruum has not been determined. The evidence indicates, however, that they are even less soluble than the acid urates. Sir William Roberts⁶ has elaborately investigated this type of urate and considers that the uric acid salt of the blood and urine is present in the form of the quadriurate. He has shown that in all probability uric acid exists in the urine of the bird as ammonium quadriurate, $C_5H_4N_4O_3 \cdot C_5H_3(NH_4)N_4O_3$.

In the few digestion experiments which have been carried out with poultry the method of von Knieriem⁷⁴ has been employed for the estimation of uric acid. A few slight modifications have been suggested, but it is performed essentially as follows: The weighed quantity of excrement is extracted with a boiling dilute solution of sodium or potassium hydroxide. The alkaline extract is filtered, the residue thoroughly washed with distilled water, and the filtrate, plus the washings, acidified and evaporated to small volume. The concentrated solu-

tion is allowed to stand in the cold to insure as complete a separation of uric acid as possible. The crystals of uric acid may then be determined gravimetrically, or total nitrogen may be estimated and a calculation made therefrom.

Much improvement over this method is demanded if reliable data are to be obtained. The uric acid is precipitated from the alkaline solution deeply pigmented and admixed with more or less extraneous organic material which presumably interferes seriously with the accuracy of either a gravimetric or nitrogen determination. Dr. Thomas Clarke, working in this laboratory, substituted a 5 per cent solution of borax as the solvent in place of sodium hydroxide. The filtration of the extract consumed less time with this modification, but much foreign matter still separated with the uric acid on acidification. The borax extract combined with the washings (together making 200 to 250 c. c. in volume) was set aside for the separation of uric acid. In check experiments we have demonstrated that a considerable proportion of the uric acid fails to precipitate from such a large volume of fluid, and unless concentration to a low volume is carried out the results obtained are misleading.

Another modification of this method has been employed by Grost.⁵¹ It is a reasonable assumption that at least a portion of the extraneous matter thrown down from these alkaline extracts by acid is in the form of proteid matter. This investigator attempted to remove this material from the extract before the separation of uric acid. The filtered sodium hydroxide extract of the excrement was diluted to a very large volume and slightly acidified, when filtration was immediately carried out. Grost states that the precipitate readily separated in flocculent masses and that filtration was performed before uric acid had apparently deposited. The filtrate was concentrated to a small volume, and, after standing, the uric acid was filtered off and weighed. This modification appears to us to be open to some criticism. No control tests on its accuracy are reported, and small quantities of uric acid separated during the process of filtration may have been overlooked.

The writer has considered the feasibility of the reliable methods employed in the estimation of uric acid in human urine. It may be said at the outset that in all of these methods it is necessary, as a preliminary step, to effect its solution. The alkali employed to this end is very likely to also remove proteid matter. Hence it is desirable to utilize a method in which the proteid and uric acid may be separated from each other or in which the presence of proteid material will not act as an interfering factor.

With the use of the Ludwig-Salkowski⁷⁵ method it seems probable that the proteid would be precipitated by the ammoniacal silver solution and redissolved on the decomposition with hydrogen sulphide. The applicability of the method of Hopkins⁷⁶ was also tested. A very

dilute borax extract of a weighed amount of excrement was saturated with ammonium chloride, when the material separated in flocculent masses. After standing several hours the material was collected on a small filter and thoroughly washed with a saturated ammonium chloride solution. The precipitate was then transferred to a small beaker with hot water, acidified, and evaporated to a volume of about 25 c. c. The precipitated crystals appeared mixed with other organic matter, which, although present in small amount, precluded either weighing or accurate titration of the uric acid with potassium permanganate.

Jolles^{77, 78} has reported a method which rests on the assumption that uric acid under certain appropriate conditions will yield all of its nitrogen in the gaseous state when decomposed by sodium hypobromite. This method did not appear sufficiently established to justify its trial in these experiments.

It has long been known that piperidine is a ready solvent for uric acid, the easily soluble salt, piperidine urate, being formed in the reaction. Tunnicliffe and Rosenheim⁷⁹ by utilizing this fact have devised a volumetric process for the determination of uric acid in human urine. They first showed that pure uric acid could be quantitatively titrated against a N/20 solution of piperidine, phenolphthalein being used as the indicator. The operation, as applied to the uric acid of the urine, was carried out in the following manner: The uric acid from 100 c. c. of urine was separated according to the directions of Ludwig-Salkowski, collected on a filter, and washed acid free. It was then transferred to a small dish with about 25 c. c. of water and titrated at boiling temperature against a N/20 solution of piperidine. Check determinations performed with the Ludwig-Salkowski method, in which the uric acid was weighed, demonstrated a very satisfactory agreement. The obvious advantage of this method as applied to poultry excrement is that the presence of proteid material does not necessarily interfere with the titration.

Kionka,⁸⁰ in a paper published in 1899, tested the adaptability of this method to the excrement of hens, and reported satisfactory results. Very small samples of meat excrement—0.2 to 0.3 grams—were selected and extracted with repeated portions of a mixture of equal parts of alcohol and ether to remove coloring matter. It is apparent that if the excrement were now titrated with a solution of piperidine that ammonia would be generated and interfere with the reaction. Kionka removed the ammonia quantitatively in the following way: The sample was treated with a little dilute hydrochloric acid to liberate uric acid from any of its salts; the mixture was left standing for several hours to allow for the separation of any uric acid which might have entered solution. Filtration was then carried out and the residue washed to free from hydrochloric acid. The excrement was now transferred by

means of 25 c. c. of water to a small beaker and directly titrated as prescribed by Tunnicliffe and Rosenheim, against a standard solution of piperidine.

Kionka employed a N/5 solution of piperidine in place of the N/20 solution used by these authors. Some criticism with reference to this method occurred to the writer. It will be noted that the samples selected for analysis were of very small quantity, and it seems questionable whether or not they would be sufficiently representative of the material analyzed. In digestion tests with grain at least the large amounts of sand and fiber present would necessitate the use of far larger samples if concordant and accurate results are to be obtained. The error of using small samples would be correspondingly greater than in the analysis of the excrement from meat feeding, and particularly in view of the fact that the uric acid content is strikingly greater in the latter material. It also appeared that the use of a N 5 solution of piperidine involved a much greater liability to error than the employment of a N 20 or N 10 solution. Thus in Kionka's analyses 0.1 c. c. of the piperidine solution was equivalent to 3.36 mg. of uric acid. Thus in view of the small amounts of excrement employed and the high percentage of uric acid a slight error would be tremendously multiplied.

A further criticism has reference to the possibility that the excrement may contain material which, in addition to uric acid, reacts with piperidine. Kionka makes no mention of any experiments designed to test this possibility. The writer's experiments in this connection with grain excrement will be presently considered. The method was first submitted to the test of repetition, samples of grain excrement of 2 grams weight being employed and a piperidine solution of N/10 strength. Great care was used to obtain uric acid of absolute purity for the standardization of the piperidine solution used in all of the analyses. A specimen of uric acid prepared by Kahlbaum was three times recrystallized from solution in dilute sodium hydroxide by precipitation with hydrochloric acid. The crystals were washed with distilled water until no further trace of chlorine could be detected in the wash water. They were then treated successively with absolute alcohol and ether, and finally dried to a constant weight at 105° C. The nitrogen content was determined in duplicate, with the result that the criterion percentage of purity was obtained. From 0.1 to 0.2 gram of the crystals was taken and titrated against an approximately N/10 solution of piperidine at a temperature slightly below boiling, phenolphthalein being added. The crystals readily dissolved and the end point was reached in two to three minutes. The titre of the solution was redetermined weekly, but was found to show no appreciable change in intervals less than one month.

Considerable difficulty was confronted in the exact determination of

the end point of the reaction, which was obscured to a certain extent by both the quantity of the suspended excrement to be handled and the pigment in the solution. A more effective method of judging the end point was performed as follows: A perforated platinum disk was sealed in the end of a long glass tube and covered with a thin layer of asbestos. A portion of the fluid was drawn through this into the tube, and solid particles being excluded, the tint of the solution could more readily be seen. The duplicate data yielded by this method were not wholly satisfactory, and it was felt that some improvement must be instituted before the results could be accepted with confidence.

The mixture of equal parts of alcohol and ether recommended by Kionka proved ineffectual in removing sufficient coloring matter from the excrement. The action of a number of solvents on 2-gram samples was tried in this respect and care was taken to ascertain whether any extraction of uric acid had been effected. Ether, benzol, amylalcohol, and acetic ether gave unsatisfactory results. Uric acid could not be detected in these extracts, but in each case the residue yielded further pigment on extraction with 95 per cent alcohol. This latter reagent, however, removed a trace of uric acid from the excrement. Absolute alcohol afforded the most satisfactory results in this connection and exerted no solvent action on the uric acid of the excrement in the grain experiments. A trace was removed, however, from the meat excrement, but it was too minute to be determined. Samples weighing 2 or 3 grams were extracted with successive portions of boiling absolute alcohol of 25 c. c. each. The residue from the first two extractions yielded a faint Scherer's test, but the additional extractive fluids resulted negatively. The number of extractions required to exhaust the excrement was dependent on the nature of the grain that was fed. Four successive treatments with 50 c. c. of boiling absolute alcohol usually sufficed for the excrement from oats feeding, but in the case of the corn samples two or three additional extractions were necessary. Four extractions removed the bulk of the pigment, but the seventh filtrate from the meat excrement still showed a faint color.

The method, in the form which we finally adopted it, was applied as follows: The material to be analyzed was thoroughly shaken and a sample, weighing from 2 to 3 grams in the case of the grain and $\frac{1}{2}$ to 1 gram in the case of meat excrement, was selected by taking small portions from various parts of the mass. The grain samples were extracted with successive 50 c. c. portions of absolute alcohol and the meat samples with 25 c. c. portions, until all soluble coloring matter had been removed. It was then allowed to dry, after which it was treated with 25 c. c. of 0.5 per cent HCl, stirred, and left in the refrigerator overnight. The material was filtered off the following morning and washed twice with water to remove the bulk of the adhering hydrochloric acid. Extraction was now carried out with an excess of boiling

N/10 piperidine solution, two to three drops of phenolphthalein being added as the indicator. The solution was filtered and the residues were washed with hot piperidine solution. The filtrate and washings were combined, the solution was acidified with hydrochloric acid, evaporated over the steam bath to a volume of about 25 c. c., and placed in the ice box. After the lapse of two or three days the separated uric acid was collected on a small filter, washed with just sufficient water to remove all traces of hydrochloric acid, and transferred to a small beaker with about 25 c. c. of distilled water. A little phenolphthalein was added and the titration conducted with a N/10 piperidine solution as described above.

As a further check upon the accuracy of the method of titration with piperidine, I have added pure uric acid to samples of previously determined uric-acid content and estimated the percentage recovered. Six trials of this character were undertaken. The following data are typical of the results: 0.1074, 0.1681, and 0.1321 gram of uric acid were, respectively, added to 2-gram samples of oats, corn, and wheat excrement, and the corresponding percentages recovered by the method were 97.3, 97.5, and 98.9 per cent.

Mention should be included here of some additional observations in connection with this method. Great care was exercised to remove all traces of hydrochloric acid from the excrement. Thus it has been calculated that for every milligram of hydrochloric acid present, a plus error of 3.65 mg. of uric acid would be involved in the titration with piperidine. Hence the presence of a relatively slight amount of the mineral acid may thus introduce an appreciable error in the uric-acid determination. That the excrement itself contains acid-reacting material was shown by the acid reaction of aqueous and alcoholic extracts toward litmus and congo-red paper and by the behavior of the same toward a N/10 solution of piperidine. As has been pointed out before, the slight impurity separated with the uric acid consisted of deeply pigmented amorphous material. The uric acid itself contained but little pigment and frequently crystallized out in absolutely colorless condition. This amorphous material dissolved on adding a few drops of piperidine to the hot liquid. This fluid was transferred to another small beaker, thus leaving in the first vessel practically all of the uric acid to be determined. The transferred solution was now titrated to the end point. The uric acid remaining behind was then treated with 25 c. c. of distilled water, the indicator added, and the titration was completed. It was thus found expedient to titrate the great bulk of the uric acid in a solution practically free from coloring matter. The quantity of uric acid dissolved served as a signal to the approach of the end reaction. The latter, however, occurred slightly subsequent to the entire solution of the uric acid, due presumably to a certain solvent action of the hot water on the substance.

The writer's attention was early called to the fact that the chemically pure uric acid, as shown in the standardization of the N/10 piperidine solution, dissolved more rapidly in this reagent than the same body separated from the excrement. It was at first thought that the absence of impurities associated with the pure uric acid might account for this result. That uric acid existed in a much more finely divided condition than in the case of the other material was also recognized. Samples of uric acid from the excrement were therefore finely ground and titrated, and the difference now very largely disappeared. This modification, however, was not attempted in the quantitative operations owing to the tendency to loss of material.

A curious fact was noted with regard to the determination of the end point of the titration. When the pink color indicating the conclusion of the titration was reached and the fluid was permitted to stand until cool, the tint deepened quite markedly. On heating to the boiling point, the previous faint color was restored, but was again intensified on cooling. In the case of other samples, the titration was stopped when the amount of piperidine added fell within 0.2 to 0.3 c. c. of producing the end color. When the titration fluids had cooled, a faint pink color manifested itself. The writer is not aware that similar observations have been previously recorded. While no explanation is offered at present for these results, it is suggested that under the experimental conditions, a slight dissociation of the piperidine urate occurs at room temperature. However, this matter had no practical bearing on the accuracy of the method.

ETHER EXTRACT.

The customary method recommended by the Association of Official Agricultural Chemists¹¹ was employed. From 2 to 3 grams of the material were dried to constant weight in vacuo at 60° C. and extracted in a Knorr's extraction apparatus for twenty-one hours. After drying and weighing the process was continued a day longer in order to insure a complete removal of the ether extract, but no additional weight was lost. The unsatisfactory nature of the present methods for fat estimation is very obvious. The ether extract in both the grain and excrement contains considerable material other than true fat represented by waxes, organic acids, pigment, etc. If such constituents passed through the digestive tract unabsorbed, the error involved would be largely counterbalanced. However, the metabolic products of the feces may comprise appreciable quantities of ether-soluble material in the form of cholesterin, organic acids, and pigments from the biliary secretion. It is thus desirable to devise methods for the determination of the nonsaponifiable material in the ether extract of both food and feces. The application of such a correction may elevate the digestion coefficient for fat to an appreciable extent.

AMMONIA.

The method of Schlossing⁸² was given consideration, but seemed to be of inconvenient length and involved the possibility of the decomposition of the proteid matter and other nitrogenous bodies by bacterial action. Distillation with very dilute sodium carbonate was undertaken, but it was found impossible at the start to carry out the distillation, owing to the extreme foaming induced by the saponification. This difficulty was obviated by utilizing the residues from the ether extract for this purpose.

It was also deemed possible that the sodium carbonate might exert some destructive action on the proteid of the excrement. Hence the method of distillation with magnesia⁸¹ was next attempted, and was found to require less time and manipulation. The results obtained were slightly lower than those yielded by the distillation with sodium carbonate, but within the limits of error. The possibility has not been overlooked that a fraction of the nitrogen of urea and possibly other extractive bodies may pass over as ammonia, but this slight error would tend to counterbalance the error committed in overlooking such substances in the crude proteid calculation.

CRUDE FIBER.

The Weende⁸¹ method was followed, although it is realized that the results obtained are not of satisfactory accuracy. Other methods have been proposed in recent years, but none as yet seem of established reliability. It has been demonstrated that the so-called crude fiber of foodstuffs is merely a mixture of true cellulose, oxycellulose, lignin, etc., the proportions of these various components differing according to the source of the material and to the time of action and strength of the solvent used.

PENTOSANS.

The directions of Tollens, as modified and adopted by the Association of Official Agricultural Chemists⁸¹ were followed. It was noted that a much longer period of drying was required for the phloroglucol precipitate than is called for in the outline of the method. Hence it was found convenient to shorten the drying process by the selection of smaller samples of the material according to a recommendation recently made by the official association.

NITROGEN-FREE EXTRACT.

This component was calculated in the excrement as follows: The sum of the percentages of the following substances was computed, namely, moisture, ash, crude proteid, ether extract, crude fiber, uric acid, and ammonia. This result was deducted from the total dry matter, the difference yielding the nitrogen-free extract.

SOLUBLE ASH AND SILICA.

Care was exercised to select particularly large samples (3 to 4 grams) for the ash determinations, owing to the high proportion of inorganic matter in the excrement. The combination was conducted in porcelain dishes in a muffle at the lowest possible red heat. Soluble ash and carbon were determined according to the official method.²¹ Especial care was taken to render the total silica insoluble. The ash, being treated with hydrochloric acid of specific gravity 1.115, was repeatedly evaporated to dryness over the steam bath and prolonged heating carried out between the successive evaporations.

DETAILS OF THE PRESENT EXPERIMENTS.

The preliminary period of each of the experiments consisted of five days, during which time the collection pan was employed. As previously stated the pan caused considerable irritation at first, but this soon disappeared.

In the first four experiments the chickens were daily offered slightly more grain than they consumed. The grain was fed for two weeks prior to the digestion experiment, the average daily requirement being thus ascertained. The food consumption did not show any great irregularities after three to five days. In the fifth trial the quantity fed was somewhat less than the appetite demanded, in order that an absolutely uniform daily consumption might be assured. It is recognized that this uniformity so gained may be somewhat incompatible with normal conditions if the food requirement was not fully met. It will be noted that in the case of subjects B and C marble was made available with gravel, but the respective amounts of these materials consumed were not determined. (See Table VI.) Gravel was withheld from chicken G both during the experimental period and for several weeks prior to that time. This experiment will receive special comment in connection with two trials with oats, in which the subjects were similarly deprived.

GENERAL SCHEME OF THE EXPERIMENTS.

The general scheme of the experiments is presented in Table I. The chickens are designated by letters, and when more than one test was carried out with the same chicken the order of their performance is indicated by a small number placed at the upper right of the letter. The total weight of the air-dried excrement in column 4 represents that of the material after being dried and ground for analysis. The other features of the table seem to be self-explanatory.

Table II records, for the entire series of experiments, the daily consumption of food and water, the output of excrement, and the body weight; also the date and duration of each trial. The relation of daily

weight of food and excrement calls for comment. Obviously the conditions of the experiment with chicken A are not wholly satisfactory, owing to the irregular food consumption during the first nine days. The data for the last four days, however, show but little variation. This fact, as well as the great length of the experimental period, would tend to counterbalance these fluctuations. It will be noted in the various experiments that the variations in the elimination of the excrement do not necessarily show an orderly correspondence to the fluctuation of grain ingestion. This feature of the results is even conspicuous in the experiment with chicken G, when the daily intake was practically uniform. This circumstance would seem to be accounted for by an inherent tendency of the chicken to irregularity of excretion. Such facts emphasize the need of experimental periods of sufficient length to overcome this source of error so far as possible.

COMPOSITION OF THE FOOD AND EXCREMENT.

The analytical data of the foods consumed are to be found in Table III. Sample 1 of corn formed the ration in experiments with chickens A, B, and C; sample 2 was fed to chickens D and G. Sample 1 of oats was employed in all of the experiments with this grain excepting that with chicken H, in which sample 2 was used. The wheat sample was employed with chicken A, this being the only wheat test that was satisfactorily completed. The beef sample was used for the experiments with chickens M and N.

Table IV exhibits the analytical data of the air-dried excrement. The variation of the samples in silica content is very conspicuous, ranging from 0.88 per cent in chicken N to 28.48 per cent in chicken C, and as the silica ingested is practically a neutral factor as regards absorption it was decided to render the data of the excrement samples more comparable by calculating the same on a moisture-and-silica-free basis. Accordingly, the data in Table V comprise the results of this computation.

THE CORN EXPERIMENTS.

Table VI shows the digestion coefficients and the balance of income and outgo of the nutrients in the corn experiments. One additional trial which was undertaken could not be completed owing to an attack of diarrhea on the third day. It may be here remarked that with this single exception the animals maintained a normally vigorous condition throughout the experiments. The appetite continued good and the excrement was of normal odor and consistency.

DIGESTION COEFFICIENTS.

Organic matter.—The digestion coefficient for organic matter in the corn experiments (Table VI) is seen to be relatively high and shows

but little fluctuation in the different tests. These slight discrepancies may be assigned to a variety of causes, such as idiosyncrasy of the animal, irregularity of food ingestion or excretion of feces, varying quantities of fecal metabolic products, etc. Jordan and Hall,⁴³ in discussing some data compiled with reference to this question, write:

In some instances the animal which gives the maximum coefficient with one food shows the minimum coefficient with another food. In no series of experiments with the same animals do the coefficients as a whole have a consistent relation with reference to individuality. It is evident that either the animals digested their food more efficiently at one time than at another or else there was an irregularity of excretion, or both. It seems reasonable to regard the former of these factors as the more influential, especially when the feces are collected for five to seven days.

Crude proteid.—Crude proteid is seen to possess a high availability, the average digestion coefficient falling somewhat below that for organic matter. The digestion coefficient for crude proteid presents greater variations in the different experiments than is seen in the case of organic matter. Such a result might be anticipated in view of the larger number of sources of error connected with the determination of this nutrient. Thus in the present experiments a correction for metabolic nitrogen has not been introduced, and this figure may exhibit relative variation in different experiments; the ready tendency of the fresh excrement to ferment with loss of nitrogen is another source of error. Furthermore, as crude proteid in the present experiments is estimated indirectly, there is a greater tendency to error than by a direct determination, for relatively slight errors in the estimation of uric acid and ammonia may be increased to appreciable quantities when their bearing on the calculation of crude proteid is considered.

Ether extract.—The utilization of the fat of corn presents a high value, and, with the exception of the case of chicken G, the data of the experiments are in excellent agreement. The experiment with chicken G calls for special mention, as the animal had no access to gravel. The lower proportion of the fat absorbed may be due to this fact, but, on the other hand, the assimilation of organic matter, crude proteid, and nitrogen-free extract is not significantly lowered. It will be noted that chickens F and H, as recorded in Table VII, digested the ether extract of oats only slightly less efficiently than the other subjects, although they were deprived of sand. The factor of individuality may have a bearing on the result noted in the case of chicken G.

It appears of interest in this connection to refer to a recent communication of St. Weiser and Zaitschek⁴⁴ on the composition and formation of goose fat. These observers fed very large quantities of maize and millet to geese, the average amount of corn daily ingested being 210 grams, that of millet 317 grams. They concluded that the body fat formed from these grains is of practically the same composition. The fats of maize and millet, though quite different in many

respects, are assimilated in such small quantities that they do not appreciably affect the large amount of fat formed from the carbohydrates of the grains. The digestion coefficient for the fat of maize as computed from their data is only 39.13, as contrasted with the corresponding average figure of the writer for hens (see Table VI) of 85.32. The difference may be referable to the enormous quantities of the grain fed by these investigators, for it seems probable that the geese were unable to digest such large amounts of fat as efficiently as smaller quantities. It should also be borne in mind that these differences may also be inherent in the different species of birds compared. These considerations apply as well in the case of millet. St. Weiser and Zaitschek obtained a digestion coefficient of 43.78, while Kalugin (see Table IX) on feeding moderate rations of the grain to hens reported 85.71.

Nitrogen-free extract.—The data for the digestion coefficient of nitrogen-free extract are satisfactorily concordant throughout the series, and the availability is very high, the average figure being 89.25. The most important constituents of the nitrogen-free extract from the physiological point of view are starch and pentosans, and it was proposed in the greater number of the present experiments to estimate the digestibility of these components.

The presence of soluble sugars in the excrement was first carefully looked for as follows: Samples of corn excrement of 3 grams each were extracted on a hardened filter with 150 c. c. of 10 per cent alcohol, a total quantity of 30 grams being so treated. The combined filtrates were concentrated over the steam bath to a volume of 50 c. c. and the residual fluid allowed to stand a day in the cold. Considerable material separated out that contained much uric acid or urate. This was filtered off and the filtrate treated according to the customary procedure for the phenylhydrazine test. The mixture was kept in the cold for several days and microscopically examined from time to time. No trace of osazone could be detected.

This negative result was confirmed by a test performed in a slightly different manner. It will be recalled that the excrement samples were subjected to extraction with boiling absolute alcohol as a preliminary step in the determination of uric acid. Five hundred cubic centimeters of such an extract, corresponding to 20 grams of excrement, were distilled until reduced to 75 c. c. This residual fluid was further concentrated to 50 c. c. over the steam bath and the phenylhydrazine test applied. No evidence of osazone was obtained. As a still further corroboration 50 grams of corn excrement were stirred with 500 c. c. of water for three hours and then filtered. The filtrate was permitted to evaporate to a volume of 50 c. c., and, after standing in the cold, was filtered and tested for osazone. In this case also no separation of osazone could be detected. These negative results suggestively indi-

cate that the excrement contained no free pentoses, and hence lead to the provisional conclusion that the pentoses of ingested pentosan material are not eliminated through the urine or intestine in unchanged form. As pointed out on page 49, pentose sugars have been demonstrated in the urine of certain mammals.

The absence of soluble sugars in the excrement has been reported in digestion experiments with other classes of farm animals. Thus Bartlett and Merrill⁸⁵ reported that the sucrose and reducing sugars in fodders, such as alsike clover, white clover, blue joint, etc., were completely digested. Ladd⁸⁶ found that the sucrose and glucose were entirely absorbed in alfalfa hay, wheat bran, corn meal, cottonseed meal, linseed meal, and oats. An exceptional result, however, was obtained on feeding turnips and mixed hay. Here the glucose was wholly assimilated, but the sucrose was available to the extent of but 78.7 per cent. Fraps⁸⁷ examined twenty-three samples of excrement from sheep to which crab grass, hay, peameal, corn bran, green rape, etc., had been fed. The conclusion was drawn that soluble sugars were entirely assimilated.

It was deemed advisable to examine the excrement qualitatively for starch before the application of quantitative methods. Five portions of corn excrement, weighing 3 grams each, were repeatedly extracted with absolute alcohol for the removal of pigment. Each sample was treated with hot water in the usual manner to gelatinize any starch present, and the aqueous extract was filtered off. Portions of 15 c. c. each of the filtrate were carefully tested with a freshly prepared iodine solution. After the addition of several drops of the reagent a faint pinkish color developed although somewhat obscured by the presence of pigment. This quickly disappeared on standing, and it was found necessary to apply several additional drops before the color would persist for any length of time. The aqueous extracts apparently contained material other than starch reacting with the iodine. The tint of the color reaction obtained suggested the presence of a trace of erythrodextrin, and as erythrodextrin is soluble in cold water its presence should be demonstrable in cold aqueous extracts of the excrement. No reaction, however, was obtained. The residues from the cold-water extraction were now treated with boiling water. The pigment had been largely abstracted by the cold water, and a distinct but faint blue coloration resulted. The misleading pinkish tinge was apparently due to admixture with pigment. The excrement from exclusive meat feeding was subjected to the above tests, but with no indication of a color reaction. A minute amount of grain excrement was ground with meat excrement, and the hot water extract of this material yielded a slightly blue color.

Samples from each experiment were microscopically examined for starch. In no case could a reaction be observed with certainty. The

starch content must therefore be exceedingly small. The only direct determination of the digestibility of starch in mammals which we have found on record was carried out by H. C. Sherman,⁸⁸ who found that the starch of wheat bran was entirely assimilated by a steer. Jordan states that he has regularly failed to detect starch in the excrement of cattle from which the unbroken grains had been removed. In view of the mere trace of starch-reacting material present in the excrement, the coefficient of digestibility of the starch alone must be very high—probably not far from 100 per cent.

St. Weiser and Zaitschek⁸⁹ have recently reported a study of the digestibility of the carbohydrates of corn and millet in ducks and geese. These observers claim that the mean of the reducing power of arabinose and xylose on Fehling's solution practically corresponds to that of dextrose. They therefore determine the pentose present in the excrement and obtain the datum for starch by subtracting the pentose figure from the total dextrose present in the hydrolyzed extract. Phosphotungstic acid was first used to precipitate reducing material other than sugars from such extracts. They report, however, that such precipitation was unnecessary, as without its use the same results were yielded. The method is open to a criticism, namely, that no mention is made of an examination of these extracts for uric acid or creatinin, which, if present, would reduce Fehling's solution.

The digestion coefficient for the starch of millet was found to be 65.80 for ducks and 91.80 for geese. The provisional deduction may be drawn that geese possess a greater digestive capacity for the starch of millet than ducks. Kalugine found that the total nitrogen-free extract in hens was assimilated to the extent of 98.39 per cent. (See Table IX.) St. Weiser and Zaitschek obtained a digestion coefficient of 95.02 for the starch of corn in geese, while the writer found that the total nitrogen-free extract of this grain was utilized in poultry to the extent of 89.25 per cent.

We have not as yet developed a satisfactory procedure for the determination of starch in the excrement, but plan to devote some study to the matter. In the application of the diastase method, uric acid and possibly other substances are brought into solution which actively reduce Fehling's solution.

Pentosans.—Considerable variation in the different experiments is manifest in the digestion coefficient for this nutrient. Such a tendency is not surprising in view of the close association of a part of the pentosan with the crude fiber and the varying values of the digestion coefficients for the latter nutrient. In two of the three experiments recorded in Table VI with regard to this matter, the pentosan material is seen to possess considerable digestibility, but the availability is very appreciably less than has been claimed for other classes of farm animals. It is possible that in fowls the ingestion of pentose sugars may

lead to the excretion of the same through the kidneys in unaltered form. Ebstein³ observed that when xylose was fed to rabbits it appeared in unchanged form in the urine. Salkowski¹ and Cremer² found that when arabinose and xylose were fed to rabbits or men, about one-fifth appeared in the urine in the same form as ingested. The muscles contained arabinose, and glycogen formation was promoted in the liver. Salkowski reported that the administration of arabinose to fowls notably increased the hepatic glycogen content and a portion of the pentose sugar was found in the excrement. How far this quantity represented material absorbed and eliminated by the kidneys could only be determined under conditions of a separation of the excretory channels of urine and feces.

St. Weiser and Zaitschek⁴⁴ studied the availability of the pentosans of millet in ducks and geese, and of maize in geese. The average digestion coefficient for millet was 21.70 for the duck and 24.10 for the goose. The assimilation of starch, on the other hand, was over 25 per cent greater in the case of the goose. The pentosan of corn was utilized to the extent of 24.20 per cent by the goose.

As indicated on page 47, the pentosans of the grain fed in the present experiments apparently did not give rise to the excretion of free pentoses. An experiment of interest in this connection was performed by Cross, Bevan, and Remington.⁴⁰ The pentosans of a weighed quantity of brewers' grains were subjected to hydrolysis with a dilute mineral acid. The acid fluid containing the free pentoses was neutralized, evaporated to small volume, and administered to a rabbit in conjunction with carrots, gelatin, etc. The animals utilized from 94.5 per cent to 98.4 per cent of the material, and no pentose or other furfural-yielding products were detected in the urine.

Crude fiber.—The digestion coefficients for crude fiber show considerable variation, which may be explicable on several grounds. The work of certain observers has shown that the crude-fiber residue will yield an appreciable quantity of pentosans when subjected to the operation for pentosan determination, and this fact alone demonstrates a lack of accuracy in the method. Furthermore, it should be emphasized that little or nothing is definitely known regarding the chemical changes undergone by cellulose in the alimentary canal. It is not known with certainty whether the data yielded by analytical methods actually represent the total quantity of unabsorbed fiber, for a fraction of the cellulose may be transformed into soluble products which, passing unabsorbed into the feces, would involve a plus error in the quantity of the nitrogen-free extract.

In addition to the deficiency of analytical method, idiosyncrasy may have a bearing on the variations of the present experiments. Fluctuations in the quantity of grinding material of the crop might be sup-

posed to exert an influence in this connection, but the data of Table VI do not bring out any orderly variations in this respect. Chicken G, however, assimilated but a minimal amount when entirely deprived of sand. An examination of Wolff's³¹ compilation of digestion coefficients shows that other classes of animals show wide fluctuations in the digestion coefficients for crude fiber, and in the majority of cases these variations are much greater than are observed in the data for the other nutrients.

It is of interest to note that St. Weiser and Zaitschek³⁴ find that the crude fiber of millet is unassimilated by ducks and geese, and the same result was yielded in the case of geese with corn.

THE OATS EXPERIMENTS.

The data obtained from these experiments are shown in Table VII. It will be noted from the general outline of these tests comprised in Table I that two digestion trials, with oats, were made with chickens A and C. The tests with oats presented somewhat more difficulty in the matter of obtaining satisfactory experimental conditions than the corn experiments. Two additional experiments were gotten under way with other animals than those designated, but owing to the production of a mild diarrhea they were discarded.

The daily statistics of food consumption, weight of excrement, water intake, and body weight are recorded in Table II. The daily ingestion of oats is considerably less than that of corn, and the monotony of the single diet is more distasteful to the fowls in the case of the former grain. The daily grain consumption does not present any striking variation with the single exception of chicken A². The oats were given *ad libitum*, except in the case of chickens B³ and E, when the amount was limited to what the animals would in all probability have eaten entire. While the daily excrement does not present a constant correspondence to the weight of the daily food, the trend of variation of the former tends to follow that of the latter.

Owing to the higher percentage of crude fiber in oats this diet calls for a greater consumption of sand than is demanded during corn feeding; hence the excrement contains a far greater percentage of ash and fiber as compared with that from corn. A representative sampling for analysis was rendered more difficult than was experienced with the excrement from corn feeding. Great labor was necessitated in grinding the samples to the requisite degree of subdivision, and the necessary precautions were observed against loss of material during this process. In six of the eight experiments gravel was offered *ad libitum*. Chickens F and H were deprived of this material for several weeks prior to and during the digestion period. In the test with chicken C⁴ marble was mixed with the gravel.

DIGESTION COEFFICIENTS.

Organic matter.—The degree of agreement of the digestion coefficients for this nutrient in the different experiments appears good in view of the possible unavoidable sources of error noted under the discussion of the corn trials. The minima and maxima, respectively, are seen to be 60.28 and 67.60 per cent. The assimilation is conspicuously lower than is shown by the corresponding figures of the corn experiments, the average difference being 21.87 per cent in favor of the corn. This matter is brought out more sharply on the graphic chart at the end of this bulletin.

Crude proteid.—As was noted under the corn experiments, the range of variation for the digestion coefficient of this nutrient is greater than is observed in the case of organic matter. The range of variability extends from 70.80 to 80.53 per cent in the experiments with the subjects which received gravel. The digestion coefficient in the case of chicken F, which had no access to sand, is quite a little lower. On the other hand, the datum for chicken H is but slightly less than the average of the subjects receiving grinding material. The mean value of all the digestion coefficients is about 10 per cent less than that of corn, a difference of considerable economic significance, which will be referred to in another section of this paper.

It may be mentioned at this point that the error incurred in overlooking the metabolic nitrogen is relatively less than in the corn experiments, as obviously follows from the fact of the greater relative percentage of crude proteid in oats. We are also aware that the character and amount of the metabolic nitrogen may vary with the various grains fed, and closely associated with this matter is the question of the quantity and nature of the nonproteid nitrogen of the food.

To what causes may the lower availability of the crude proteid of the oats be assigned? The proportionately greater quantity of crude fiber present, as compared with corn, may exert a protective influence on the crude proteid, thus tending to shield a portion from the full action of the gastric and pancreatic enzymes. The inferior palatability of the oats and the smaller consumption, as compared with corn, are also possible factors. On the other hand, the crude proteid of oats may possess an inherently lower digestibility, aside from other influences. This possibility gains additional weight in view of the observation that the individual grains of oats regularly appear in the excrement thoroughly disintegrated. The excrement of chickens F and H, which received no sand, did not apparently differ in appearance in this respect from that of the other subjects which had received a full quota with the food.

Ether extract.—The series of digestion coefficients for this constituent exhibit a little greater variation than was observed in the corn experiments; the highest and lowest values being, respectively, 85.44

and 77.19 per cent. The mean availability is slightly less—about 3 per cent—than the average for corn, but the difference is hardly of sufficient size to carry economic weight. It is important, however, to consider that despite this slight discrepancy, the oats grain contains an appreciably smaller content of ether extract as compared with corn. With regard to the crude proteid, however, the reverse relation holds true; while the percentage of crude proteid is greater in oats, there is a pronounced difference in favor of the availability of this ingredient in corn.

The residues from the ether extracts of the excrement from both corn and oats were examined for the presence of cholesterin-like material by a method described on page 86. Crystalline material was obtained readily responding to the Salkowski reaction with sulphuric acid and chloroform. The writer is not aware that either the excrement or the bile of birds has ever been examined for the presence of cholesterin. As both corn and oats contain phytosterin, it seems probable that the material here isolated may partly owe its origin to the cholesterin-reacting substance of the food as well as of the bile. Regarding the exact form of the cholesterin of the excrement, nothing can be said here, as the reduction processes of the intestine vary in different animals both as to character and extent. Thus the horse excretes a modification of cholesterin known as hippokoprosterin;" in the feces of the dog it is eliminated unchanged; while in the intestine of man koprosterin is the distinctive term for the altered cholesterin found. Thus it appears plausible that the bird may excrete a peculiar modification of this body. In view of the relative shortness of the intestine and the rapid digestion in birds, it seems likely that less bacterial action would come into play and hence less modification of cholesterin material in the alimentary canal as compared with the animals above referred to.

Nitrogen-free extract.—The digestion coefficients for this constituent are much inferior in value to those of corn, as would be inferred from a comparison of the data for organic matter. The limits of variation for all the experiments with oats are 65.19 and 74.99 per cent. The mean value for the digestion coefficient of corn is 18.48 per cent higher than the corresponding figure for oats. The larger percentage of crude fiber in the oats may be in part responsible for this difference. If this is the case the crude fiber would appear to depress the availability of the nonstarch components of the nitrogen-free extract as the assimilation of starch seems to be nearly complete. Repeated qualitative tests were applied to all the samples of excrement as described under analogous experiments with corn, and a slight positive reaction could be demonstrated, except in case of chicken H. There seemed to be mere traces present in accordance with the results of the corn experiments. The absence of soluble sugars in the corn excrement was also found to hold true for the samples from the oats experiments.

Pentosans.—There is a lack of uniformity in the digestion coefficients for this nutrient throughout the series. This finding is not surprising when the wide variations in crude fiber assimilation are given due regard. As is indicated on page 48, a tendency to a correspondence between the digestion coefficients of these nutrients would not seem inconsistent. Aside from the second experiment with chicken A, the general trend of the data point in this direction. The availability of the pentosans of oats in poultry, on the basis of our experiments, appears to be much lower than has been observed by Fraps²⁷ in digestion trials with sheep on this grain.

Crude fiber.—The proportion of crude fiber utilized is seen to show considerable fluctuation, varying in the experiments where the subjects were given access to sand from 4.25 to 10.64 per cent. The general tenor of the data indicates a lower absorption than that noted in the tests with corn, but owing to the greater quantity of the constituent consumed in oats, the absolute amount assimilated exceeds that of corn. Broadly speaking, the crude fiber of oats seems to be of insignificant food value and more particularly when considered in connection with the digestion coefficient of this nutrient in other classes of animals.

Having already briefly considered some of the possible causes to which discrepancies in the different experiments relative to crude-fiber absorption could be attributed, the writer would add here the suggestion that variations in the retention of fibrous material in the alimentary canal may be a factor in this connection. At any rate it seems plausible to suppose that the physical nature of such material would render it more liable to irregularity of excretion than in the case of the other nutrients.

As observed in the corn series, the consumption of sand and assimilation of crude fiber seem to show no orderly variations. Chickens F and H apparently utilized crude fiber as efficiently as the other animals, despite the fact that they had not consumed sand for three weeks. Such observations tend to support the contention that fluctuations in the value of the digestion coefficients are not, essentially at least, associated with variations in the sand ingestion.

THE WHEAT EXPERIMENTS.

Although six digestion experiments were undertaken with wheat but one of the series was completed. This difficulty was due to the digestive disturbances engendered by the exclusive use of this grain. After varying periods of a few days, the animals exhibited a marked loss of appetite, with general symptoms of bodily depression, and the feces emitted a markedly abnormal odor. Diarrhea was early manifested. On changing the diet to corn or oats the appetite was rapidly regained, and general normal conditions were soon restored. The following is descriptive of a typical experiment: An active, vigorous

hen was fed 50 grams of corn daily for a period of two weeks, the appetite remaining keen during this time and the daily consumption uniform. The daily ration was now changed to the same quantity of wheat. The note-book record shows that the consumption for the first day was 40 grams, that of the second 35, of the third 29, and of the fourth 22, on which date the feces appeared of abnormally soft consistency and a marked putrefactive odor was manifest. On reverting to the corn ration these unfavorable symptoms disappeared within forty-eight hours.

Our experience has been paralleled by Dr. Thomas Clarke, who carried out five wheat-feeding tests with fowls, only one of which was completed under normal conditions.

In Table II are included the daily statistical data of the single experiment which was completed with chicken A. The suggestion may be offered that this animal may have resisted the untoward effects of the diet by virtue of idiosyncrasy. The writer would also emphasize the point that he fully realizes the limited value of results based on but one digestion test, and therefore offers the data with a greater reserve than in the other experiments.

DIGESTION COEFFICIENTS.

The daily consumption of food in this experiment was maintained at practically a uniform level, and there is a rough correspondence between the slight irregularities of food ingestion and the output of excrement. The assimilation of organic matter is but slightly less than the utilization of this nutrient in corn. The digestion coefficient of crude proteid is intermediate in value between that of corn and oats, but is nearer the latter.

The most conspicuous feature of these results is the low digestion coefficient for the ether extract. This observation is doubly significant when associated with the inferior proportion of ether extract in wheat. If further experiments confirm this indication, the result will assume a most important bearing on the use of this grain in poultry dietaries. The injury to the fowl following the exclusive use of wheat may be due to the poorness of the grain in fat and the low availability of this nutrient. It may be of interest to mention that Grost observed in hens a very low assimilation of the ether extract of rye, a grain which somewhat resembles wheat in its low percentage of ether extract. No reference, however, is made to any interference with the digestive processes. Pflüger⁹³ has published an observation which should be mentioned in this connection. He found that the exclusive feeding of horse meat led to a marked diarrhea in dogs, and suggests that this result may be partly assignable to the deficiency of the tissue in fat.

The nitrogen-free extract of wheat in this experiment is digested in a proportion only slightly less than that determined for corn. Quali-

tative tests, carefully repeated, failed to demonstrate the presence of soluble sugars in the excrement of this animal; starch was not searched for.

The data for crude fiber are not recorded in the table owing to the fact that the content of this substance in the excrement slightly exceeded that of the food. The first estimation of crude fiber was made in duplicate in both the food and the feces. The results so obtained were confirmed by a further duplicate determination. Irregularity in excretion may be concerned with this discrepancy, and it is possible that crude fiber retained from the preliminary period is eliminated with that fraction belonging to the wheat of the collection period. While the time of the present experiment would seem to be sufficient to acquire definite data on the point just referred to, it is necessary to considerably prolong the period to place the matter beyond doubt.

THE MEAT EXPERIMENTS.

The data on the composition of the meat employed in the two experiments with this diet are presented in Table III. Tables IV and V exhibit the composition of the excrement. Each experiment was preceded by a preliminary period of five days, during which time the same daily quantity of meat was given as in the digestion period. The chickens had received a sole meat diet since the date of purchase, three weeks prior to the beginning of the preliminary period. During the entire time no digestive derangement resulted, nor were any of the symptoms present described by Kionka (see p. 23) as ensuing from excessive meat feeding. The daily ration was immediately and readily consumed throughout the preliminary and digestion periods. The monotony of the diet did not markedly interfere with the palatability, as was seen in the grain tests, but the small quantity of material offered may be concerned with this difference. Although the subjects suffered a very gradual but progressive loss of weight, greater bodily activity and vigor was maintained than in the digestion experiments with the grains.

DIGESTION COEFFICIENTS.

In view of the fact that only two meat experiments were performed, it is realized that even greater reserve should be exercised in a consideration of results than in the grain experiments. The balance of income and outgo with the digestion coefficients is presented in Table VII. The agreement between the two experiments is seen to be quite satisfactory in the case of all three nutrients considered—that is, organic matter, crude proteid, and ether extract. Nitrogen-free extract is disregarded, owing to the minimal quantity of carbohydrate material in meat. A closer agreement between the digestive coefficients for the nutrients of meat would be looked for than in the

of grain in view of certain analytical considerations. The estimation of the crude proteid of meat yields more accurate data than is the case with corn or oats. This follows from the high content of proteid matter in the dry meat and the corrections introduced for peptone, albumose, and meat-base nitrogen. The meat excrement possesses a higher content of crude proteid than the material from grain feeding, and this difference renders the error of indirect determination of this constituent proportionately less. The strikingly high quantity of uric acid in the meat excrement would a priori insure a smaller error of analysis, and this same consideration applies to the ammonia.

A cursory glance at the comparative analytical data on the composition of both the food and resulting excrement brings out sharply the more heterogeneous character in the case of the grains. The absence of carbohydrate and crude fiber, at least in appreciable quantities, from meat indicates that sampling for analysis would be the more satisfactory with the food and excrement in the meat experiments. This would also incline us to the view that the digestion coefficients for organic matter in different experiments would result in closer agreement. It should also be borne in mind that a correction for "residual nonproteid nitrogen" was taken account of in calculating the percentage of the meat excrement proteid. This nitrogen represents at least a part of that not in the form of crude proteid, uric acid, or ammonia. It was estimated as follows: Three grams of excrement were weighed out and heated with 300 c. c. of water over the steam bath for thirty minutes, the loss by evaporation being replaced from time to time. The water was now allowed to boil for a few minutes, when filtration was carried out. The filtrate was made up to 500 c. c. in a properly graduated flask. Total nitrogen, ammonia, and uric acid were estimated in aliquot portions. A large number of tests demonstrated that no proteid matter was removed by these hot-water extracts. The nitrogen, exclusive of uric acid and ammonia, was calculated from the data obtained, and the correction applied in the calculation of crude proteid. The writer has not overlooked the consideration that there may be "residual nonproteid nitrogen" in the excrement undissolved by hot water.

COMPARISON WITH GRAIN COEFFICIENTS.

It may be of value to contrast the average digestion coefficients of the meat nutrients with the corresponding figures obtained in the grain tests. The assimilation of organic matter and ether extract does not depart noticeably from the values obtained for corn. Crude proteid is utilized to a greater extent than was found in the case of corn. This high value for crude proteid is particularly significant as associated with the strikingly high proportion of proteid material in meat. It would be of interest to determine the coefficient for crude proteid

after the ingestion of larger quantities of this article of diet. It appears not improbable that with extremely large quantities the coefficient would be lowered, especially if the amount consumed overtaxed the digestive capacity of the animal.

The proportionate quantity of ether extract in the meat consumed is less than that included in the grains fed. The value of the digestion coefficient, however, does not indicate any essential difference in the digestive capacity of the chicken for animal and vegetable fat. It is planned at a future date to undertake digestion studies with beef when the material is consumed with a balanced diet of a predetermined digestibility. In this way it may be determined whether the digestion coefficients of the meat fed as a sole diet differ from those when it is combined with other food materials.

In the above considerations of the digestion coefficients of the writer's experiments, it should be borne in mind that the digestibility of the nutrients may show some variation under conditions differing from those here imposed. Thus unrestrained exercise in the open air would tend to raise the general body metabolism, and hence increase the digestion coefficients over the value secured under conditions of experimental confinement. The possibility must also be considered that the availability of the grains may undergo some modification when fed as part of a mixed ration rather than when consumed as a sole article of diet. The proportion of fibrous material in the ration must be considered. The relative palatability may also show some change when the grain in question is offered as a component of a mixed ration. Thus the proportionate consumption of oats to corn may increase when the two grains are fed together. In the open air and with access to a wide range, the appetite of the animals, even for the single grains, would tend to increase, and the augmented consumption would in all probability lead to increased weight as compared with the same under experimental conditions such as those described in the present paper.

THE METABOLIC NITROGEN OF THE EXCREMENT.

In Table VIII the few data obtained for nonproteid nitrogen of the excrement removed with various solvents are tabulated. The determinations obtained with the extracts of 95 per cent alcohol were found to be misleading, as slight traces of uric acid were demonstrated in the residues from such extracts. These extracts also contained an organic amorphous nitrogenous substance which is further described on page 87, and may consist of alcohol-soluble proteid. It can not be said at present whether this is a metabolic product or derived from the grain. The term "fecal nitrogen" as employed in the table includes not only the nitrogen of the feces, but additionally the urinary nitrogen, exclusive of uric acid and ammonia. Table VIII shows that the "fecal nitrogen" of the excrement samples from chickens B and

C in the corn experiments contained 70.33 per cent and 59.88 per cent, respectively, of nitrogen abstracted by 95 per cent alcohol. The sample from the second oats experiment with chicken A comprised 46.36 per cent metabolic nitrogen.

The importance of apparently insignificant amounts of metabolic nitrogen should be fully recognized in experiments with poultry, in which animals the absolute quantity of nitrogen daily excreted is so small. Thus the excrement of the corn experiments with chicken B yielded only 0.12 per cent of ether-soluble nitrogen, but a correction for the same raises the digestion coefficient for crude proteid from 86.63 per cent to 87.98 per cent. In the oats experiment with chicken B the ether-soluble metabolic nitrogen was 0.12 per cent and the corresponding correction elevates the digestion coefficient from 79.39 to 80.11 per cent. In the second oats experiment with chicken A a correction for 0.10 per cent raises the digestion coefficient 2.72 per cent. The correction for acetic-ether nitrogen in the case of the last-named experiment and of chicken B² is seen to be rather greater than in the corresponding ether extracts.

The nitrogen removed by absolute alcohol was determined in the case of two experiments. These results are of doubtful value, owing to the probable solution of the organic amorphous nitrogenous material, which may be proteid in nature, and which was noted in the residue from the 95 per cent alcoholic extracts. It appeared to be removed to a slight extent. When the crude proteid calculations for the experiments with chickens E and F were checked for this nitrogen value the percentage of absorption in the former case was altered from 72.65 to 77.17 per cent, and in the latter from 67.75 to 74.07 per cent.

As to the form or forms of the metabolic nitrogen extracted by ether or acetic ether, little may be said here. Bile pigments, lecithin, and certain decomposition products of the bile salts may be dissolved by ether. Little is known relative to the composition of bile or the modifications undergone by the constituents in the intestines of the fowl. It appears probable that absolute alcohol extracts metabolic nitrogenous material in addition to that removed by ether, despite the fact that the former reagent may dissolve a certain quantity of zein proteid. The excrement, as we have previously observed, contains considerable mucus, and this material, in addition to the nuclein of desquamated cells of the alimentary tract, may contribute much of the metabolic nitrogen. These two sources may largely account for the high percentage of metabolic nitrogen observed by Paraschtschuk⁵⁴ (see next page). The comparison of the average digestion coefficients for organic matter and ether extract indicates a satisfactory agreement between the results of the present experiments and those of Paraschtschuk, and the same statement applies to the nitrogen-free extract. Paraschtschuk makes no mention of an examination of the excrement for starch.

A COMPARISON OF THE PRESENT WITH PREVIOUS EXPERIMENTS.

The averages of the digestion coefficients of corn are presented in Table VI and those of oats in Table VII. These averages are tabulated together in Table IX, and are graphically represented in the smaller chart at the end of this bulletin. Table IX was constructed to bring out the comparison between the data of the present experiments and those published by other experimenters relative to the digestive coefficients of poultry. There have also been included average digestion coefficients established for other farm animals under conditions of diet as closely analogous as could be found.

We would call attention to the unreliability of the average coefficients of digestion for crude fiber in the corn and oats experiments. In view of the rather wide variations in results, it seemed misleading to attach any importance to such figures. References will be made to some of the sources of variation to be considered in the comparison of the digestion coefficients of the same diet presented in Table IX.

EXPERIMENTS WITH CORN.

In the second line of Table IX the average digestion coefficients for corn established by Paraschtschuk⁵⁴ are presented. Owing to the artificial anus established in the subjects of his experiments, his data are not strictly comparable with those of our digestion trials. No mention of the accessibility of gravel is made and the very small quantity excreted by the animals would indicate that none had been offered. Furthermore, this investigator claims that approximately 50 per cent of the fecal nitrogen exists in the metabolic form for which a correction is applied in the calculation of crude proteid. It is seen that our average digestion coefficient for the crude proteid of corn is nearly 9 per cent less than that observed by Paraschtschuk. Assuming for the moment that his data for the metabolic nitrogen represent accurate values and applying his average corrective figure to our digestion coefficients, the respective results, whether coincidentally or otherwise, show an excellent agreement.

It is of importance to consider the method employed by Paraschtschuk for metabolic nitrogen with reference to certain criticism. The directions of Pfeiffer⁵⁴ were followed. A weighed quantity of excrement was digested with 1 per cent (Merck) pepsin solution in 0.2 per cent HCl for twenty-four hours. The undigested material was filtered off, washed, and the nitrogen content determined. This result was assumed to represent the metabolic or nonproteid nitrogen of the feces. No mention is made relative to a check upon the activity of the pepsin solution employed, and there was apparently no attempt made to test the undigested residue for proteid matter with a view to ascertaining whether all of this ingredient had entered solution. The possibility is not referred to that a portion of the unknown

metabolic nitrogen may be dissolved by the 0.2 per cent HCl employed. As has been previously pointed out, this method, if accurate, is not applicable to excrement samples, owing to the presence of urinary constituents.

In the light of a recent paper by Szumowski⁶⁶ it seems unlikely that the proteid matter of the excrement would be completely dissolved in a period of twenty-four hours. Szumowski performed artificial digestion tests with the zein of corn and found that the substance is dissolved only very slowly in both pepsin and trypsin solutions. Portions of a pure zein preparation were placed in active peptic and tryptic solutions and at the end of several days no marked digestion had occurred. A finely divided preparation was digested for fourteen days before complete digestion. Samples of varying weight were tested with peptic and tryptic extracts, and solution of the material was never obtained in less than seven days.

Szumowski estimates that 50 per cent of the proteid of corn is present in the form of zein. This makes it appear probable that a portion of this material would appear in the excrement. He fed large quantities of corn exclusively to geese. After varying intervals the animals were killed and the various tissues extracted with 90 to 96 per cent alcohol to remove any zein which might be present. The results were negative, showing that zein is transformed to another form of proteid before it is built up into the tissues. When injected directly into the circulation of geese it exerts a marked toxic effect and accumulates in the liver.

A substance separated from the excrement by 95 per cent alcohol, which corresponds in some respects to the properties of zein proteid, is described on page 87. If unaltered zein is actually present in corn excrement, Paraschtschuk seems to have committed an error in assuming a complete solution of the excrement proteid in twenty-four hours on treatment with pepsin solution. If so, a fraction of his data for metabolic nitrogen is probably represented by undissolved zein. This criticism is, of course, applicable to all digestion experiments in which zein-containing grain has been fed, whenever the digestion method for the estimation of metabolic nitrogen has been employed.

The writer has carried out a number of digestion tests with pepsin and hydrochloric acid. A number of samples of corn and oats excrement were digested with an active Merck pepsin solution exactly under the conditions prescribed in Paraschtschuk's experiments. In all cases the washed and dried residue from the twenty-four hours' digestion gave a distinctly positive reaction for proteid matter with Millon's test. The digestion filtrates yielded a response to the biuret reaction. A control solution of the pepsin preparation responded very faintly to this test, but the greater intensity of the reaction in the former case indicated the solution of proteid material. Egg albumen was

rapidly digested to the proteose and peptone stage in the presence of the excrement, thus intimating that the latter contained no material inhibitory to the action of the enzyme. These residues were further digested for two days and the filtrates and washed residues again examined. Positive results were obtained, thus suggesting a very gradual solution of the proteid substances. After digesting these residues for a period of a week, the residues still responded to Millon's test, thus indicating the presence of indigestible proteid or certain substances belonging to the aromatic series, such as indol, skatol, etc., reacting with this reagent. The aromatic bodies named would presumably be present in too minute quantity to respond to Millon's test under these conditions.

The writer is well aware that the solution of proteid observed in the above tests does not necessarily involve digestion of the same. The following experiment was undertaken with reference to this matter. A large number of excrement samples were exhaustively extracted with hot 95 per cent alcohol to remove as much pigment as possible. In this case the zein proteid would also be largely or wholly removed. The dried materials were subjected to digestion with 0.2 per cent HCl, without pepsin. Otherwise the conditions exactly paralleled those of the experiments just described. No proteid was found to be dissolved by the acid. It thus appears probable that water-soluble proteid matter of the excrement, if present, was rendered largely insoluble by coagulation during the original drying process with alcohol.

For several reasons the average digestion coefficients reported by Fields and Ford⁶² are not comparable with our data. The excrement in the experiments of these investigators was not obtained by accumulation in a collection apparatus during the day, but was taken from the bottom of the cage pen. It is stated that the legs of the animals were washed at the beginning and end of each digestion period and the adhering dung collected. In this way a serious loss of nitrogen by fermentation of the excrement might occur. A description of the analytical methods which were employed is lacking. Analytical data are tabulated for both "protein" and "albuminoids," but no reason is assigned for such distinction of terms, and in the literature of digestion experiments it is customary to use them synonymously. The digestion coefficients for crude proteid from both the whole-corn and cornmeal experiments of Fields and Ford are seen to be far lower than the corresponding figures reported by the writer. The data for ether extract, on the other hand, are lower in the present tests. A lack of thoroughness in the extraction with ether is a plausible source of the latter discrepancy.

The above-mentioned experiments of Fields and Ford furnish some data relating to the effect of grinding on the digestibility of a grain.

In the tests with whole corn and cornmeal no influence is manifested. The results with Kafir corn were of an inconclusive character, and the digestion coefficients of whole cowpeas exhibited but slight variations from those of cowpea meal.

EXPERIMENTS WITH OATS.

The average percentage of assimilation of the nutrients in our oats tests is contrasted with the data of the single experiment performed by Grost⁵¹. Such a comparison offers the basis for suggestive rather than definite and conclusive statement, more particularly as the results of Grost rest on the slender basis of but one trial. The digestion coefficient for crude proteid is reported as about 11 per cent higher in the writer's experiments. The character of the analytical method for crude proteid employed in the respective experiments may be responsible for this difference. The corresponding results for ether extract indicate a rather satisfactory agreement, a concordance not unexpected in view of the identity of the method employed. It will be noted that Grost finds but a trace of crude fiber assimilated. That his datum for nitrogen-free extract is at a lower value than that determined by the writer would follow from the comparison of the coefficients for crude proteid brought out above.

These differences may be also partly referable to certain features in the conduct of Grost's experiments. Thus the subjects were confined in a perfectly stationary position, in order that the excrement might be quantitatively collected, and no mention is made relative to the consumption of sand. Such close confinement without bodily exercise in such active animals may considerably depress the digestion coefficients of some or all of the nutrients by a lowering of the general body metabolism.

EXPERIMENTS WITH WHEAT.

In the comparative consideration of the wheat experiments there are several sources of variation to be borne in mind. Kalugin^{49,50} computed the crude proteid content of the feces on the basis of the data for total uric acid and ammonia nitrogen. The ammonia was estimated by calculation only, on the assumption that this constituent was present entirely in the form of ammonium quadriurate. While Roberts⁶ has adduced much evidence in favor of the view that the uric acid is so combined, it has not been demonstrated that all of the ammonia is present exclusively in this form. Such an error would decrease the actual digestion coefficient for crude protein. Lehmann⁵³ performed his wheat experiment under the conditions of an artificial anus and reported a satisfactory condition of the animals following the operation. As we were unable to locate the reference to his original paper, no information could be gained regarding the analytical methods pursued.

The data for organic matter from the three sources are strikingly concordant. While the digestion coefficient for crude proteid is about 20 per cent higher in the writer's experiment as contrasted with that published by Kalugin, Lehmann's figure agrees with our result. The absorption of ether extract is low in all three cases, but the finding of Lehmann is much inferior to the results secured by Kalugin and the writer. The digestion coefficients for crude fiber in these experiments are utterly at variance. Possible explanations for such confusion of comparative results have been advanced at a former place.

EXPERIMENTS WITH PEAS AND BARLEY.

In the experiments of Kalugin,⁵⁰ Lehmann,⁵³ and Grost⁵¹ the data published by Kalugin and Lehmann on the digestion coefficients of peas call for some comment. With the exception of organic matter the availability of the nutrients is the higher in the case of Kalugin's experiments. The results of the digestion experiments with barley performed by Kalugin and Grost present a notable agreement, the more striking in view of the several sources of error incident to experimental work of this character. The agreement is especially pronounced in the case of ether extract and crude fiber.

THE DIGESTION COEFFICIENTS OF POULTRY AND OTHER FARM ANIMALS COMPARED.

It is of interest to contrast the data for the assimilation of the nutrients of foodstuffs in poultry with those obtained with other farm animals under conditions of diet corresponding to each other as nearly as possible. Such comparative data are presented in Table IX. It will be noted that the digestion coefficients for ruminants, horses, and hogs, with the exception of the wheat experiments, are quoted from the compilation of Wolff.⁹¹ These data seemed to afford a sounder basis of comparison than the few American experiments available, owing to the larger number from which the average figures were drawn. In some cases comparable data could not be found in the American literature. In fact, the number of experiments on record, especially with ruminants and horses, must be necessarily small, owing to the difficulty of sustaining such animals on a diet exclusively composed of grain.

Corn.—Ruminants, horses, and hogs assimilate the organic matter of corn in approximately equal proportions. The digestion coefficients for this nutrient in poultry shows but slight variation from that of these three classes of animals. Poultry and hogs exhibit approximately the same digestive capacity for the crude proteid of corn, while the digestion coefficient for ruminants and horses is markedly less. On the other hand different relations hold true for the digestibility of the ether extract. Ruminants and poultry possess approximately

equivalent digestion coefficients while horses and hogs utilize a much smaller proportion of this nutrient. The digestion coefficients for crude fiber are much higher in ruminants, horses and hogs, although the figures for the last-named class stand the least removed in value from that of poultry. The proportionate digestibility of the nitrogen-free extract in poultry is seen to be slightly less than in the other three classes of animals.

Oats.—In a careful search of the literature on the subject we have been unable to locate experiments dealing with the digestibility of oats as a sole diet in hogs. The table, therefore, only institutes comparisons between the digestion coefficients of ruminants and horses, and poultry. The organic matter of oats is utilized in a proportion somewhat less in poultry as contrasted with ruminants and horses. The digestion coefficient for crude proteid is much inferior in poultry as compared with that of horses. Ruminants, however, exhibit only a slight superiority over the assimilation observed in poultry. In regard to the ability to digest the ether extract, there is practically no difference between these two classes of animals, while the availability in horses appears to be considerably less. We have previously called attention to the fact that the data for crude fiber in the poultry experiments show generally a lower proportion of assimilation in oats than in corn. It is an interesting similarity that the same relation holds true for this constituent in the digestion tests with ruminants and horses. As might be a priori surmised, the digestion coefficient for the crude fiber of oats is far greater in ruminants and horses than in poultry. On the basis of these comparative results, the general nutritive value of whole oats for poultry appears to be less than for ruminants and horses.

Wheat.—The few figures on record in regard to wheat afford but a slender basis for comparison. A review of the literature revealed but one study⁵⁶ of the digestibility of whole wheat in hogs, and apparently no experiments have been performed with horses and ruminants, either under conditions of exclusive wheat feeding or where the grain was fed with a basal diet of known digestibility. The digestion coefficient for crude proteid is somewhat lower in pigs than in poultry, if the data of Kalugin's and the writer's experiments are taken as the basis of comparison. Ether extract is absorbed to a slightly greater extent in the pig, while the utilization of the nitrogen-free extract appears to be less. It is of interest that, corresponding to our results in the case of poultry, hogs digest the ether extract of wheat in much lower proportion than that of corn.

Peas and barley.—Attention is called to the data contrasting the digestion coefficients of peas^{50,53} in poultry and those determined for ruminants,⁶¹ horses, and hogs. The organic matter appears to be utilized to a slightly greater extent in horses than in poultry, but in

ruminants and hogs the assimilation is very much greater. Further discussion of the comparative results seems futile, owing to the wide discrepancies between the data of Kalugin and Lehmann, the only poultry tests with peas on record. The statement seems justified, however, that the availability of the crude proteid of peas is high in all of these animals. The barley^{50,51} digestion tests with poultry seem sufficiently concordant to permit of a comparison with the results of digestion experiments secured with the other classes of animals referred to. The poultry coefficients for the crude proteid of barley are not greatly removed from those of ruminants, horses, and hogs, and they correspond more closely to the two latter classes than the first named. The organic matter is utilized to a less extent in poultry than in any of the other animals with which they are contrasted. In their capacity to absorb the ether extract poultry resemble hogs. In the case of horses the ether extract coefficient was much lower; ruminants exhibited a considerably greater percentage of absorption.

GENERAL DISCUSSION OF THE DIGESTION COEFFICIENTS.

A comparison of all the poultry digestion coefficients of Table IX reveals several points of practical interest. The organic matter of corn is digested to a greater extent than was observed in any of the other foods studied. The organic matter of peas and barley is absorbed in approximately equal proportion. The digestion coefficients for crude proteid possess the highest value in the case of corn and peas. There are but slight variations in this value as regards oats, wheat, and barley. The percentage of assimilation is considerably lower in the case of buckwheat than is recorded for the three last-named grains. The digestion coefficient for ether extract is approximately of the same value for corn, oats, and peas; slightly higher for buckwheat. Allusion has been made on page 49 to the small significance which is to be attached to the data for crude fiber. The digestion coefficient for this nutrient seems to tend to be higher in corn than in any of the other grains. Barley yields but a trace of digested crude fiber, and the percentage of utilization is slight in oats, rye, and buckwheat.

Another point of interest brought out calls for mention, namely, the conspicuously inferior absorption of the ether extract of both rye and wheat. This is particularly significant when associated with the fact that the percentage content of fat itself is very low in these grains, more markedly so in the case of rye. This low assimilation may be attributed to both the small quantity ingested as well as to the inherently low digestibility of fat itself. The high absorption of ether extract and the low availability of crude protein in the case of buckwheat are conspicuous features of the table. These comments also apply to the data quoted with reference to millet.

In view of the above considerations, the fuel value of the assimilated food per 100 pounds body weight is greater in poultry than in the larger farm animals compared above. It would be very desirable to directly estimate the fuel value of the assimilated food under various conditions with the bomb calorimeter. Such a study is not possible under conditions of a common pathway for the excretion of urine and feces, and it is evident that the establishment of an artificial anus would be necessary. The data for fuel value here presented are regarded as but approximations.

The comparative data representing the actual assimilation of nutrients per 100 pounds of the grain fed present several features of interest. (See Part IV of Table X.) If an equal consumption of the organic matter of corn, oats, and wheat could be effected, the wheat would presumably yield a slightly greater quantity of crude proteid than the oats. Corn, on the other hand, would yield a much smaller quantity than oats. When the ether extract is considered, these relations are quite reversed, corn yielding the greatest amount, while wheat is conspicuously deficient. With regard to the nitrogen-free extract, there is but a slight difference between corn and wheat, while the assimilation of this nutrient in the case of oats is strikingly inferior. The preceding statements are based on the assumption that the digestion coefficients would not fluctuate with varying amounts of food ingested. The latter possibility, however, must be borne in mind, and investigation in this connection is called for.

The question of palatability is of importance in connection with the value of the digestion coefficients. Thus not only is the consumption of oats much inferior to that of corn, but the actual percentage of assimilation of the proteid of oats is much less than that of corn. The proportion of ether extract in whole oats is inferior to the latter grain, and the availability of this nutrient is hence correspondingly less in oats. The inferior availability of the nitrogen-free extract of oats as compared with that of corn depends both on the lesser consumption and lower digestibility. The matter should be emphasized that in incorporating grains into poultry rations the relative palatability should be correlated with the digestion coefficients.

THE COST OF THE PRINCIPAL NUTRIENTS.

The great value of information regarding the actual cost of assimilated nutrients in the various poultry foods, such as the grains; the milling by-products, as bran, middlings, etc.; cut bone, the hays, grasses, etc., is obvious. The poultryman himself, would be competent to calculate these data, provided the digestion coefficients of the various feeding stuffs were available. When such coefficients have been established, he will be enabled to select the nutrients of the dietary from those foods which in his locality combine the highest digestibility with the cheapest cost.

In Part V of Table X we have recorded the cost of each constituent per pound of dry weight as calculated when the actual digestibility is taken into consideration. The following prices per bushel were assumed for the three grains: Corn at 60, oats at 40, and wheat at 80 cents. Although market ratio shows great fluctuation, the relative prices here adopted are thought to be fairly representative. The figures obtained are of suggestive interest. The most marked feature is the cheaper cost of the three nutrients of corn as compared with both those of oats and wheat. The crude proteid of oats costs practically 50 per cent more than that of corn and the same constituent in wheat is slightly below the cost in oats. The worth of the ether extract of wheat is conspicuously high, being over 50 per cent more than this nutrient furnished by corn. The nitrogen-free extract has a purchasing price strikingly higher for oats than the other two grains. The provisional conclusions seems justified that the nutrients of corn are not only assimilated in higher proportion, but they are cheaper than in the case of the oats and wheat. With equal consumption oats will theoretically yield a greater quantity of crude proteid than corn, but from the economic standpoint it would probably in most cases be of greater advantage to feed this constituent in the latter grain. Obviously, it would be bad economy to employ wheat for the ether extract of a ration, but the crude proteid and nitrogen-free extract of this grain may often be more economically fed in mixed rations than those of oats.

Table XI presents the values of the income, outgo, and assimilated quantities of the nutrients. In reaching these calculations it has been taken for granted that, for practical purposes, the crude proteid, ether extract, and nitrogen-free extract are the only constituents of nutritive value. The cost of these ingredients per kilo weight is given herewith:

Cost per kilogram of constituents of corn, oats and wheat.

Constituent.	Corn No. 1.	Corn No. 2.	Oats No. 1.	Oats No. 2.	Wheat.
	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>
Dry matter	2.65	2.64	2.99	3.02	3.23
Organic matter	2.69	2.68	3.10	3.15	3.30
Crude proteid	2.71	2.73	3.50	3.53	3.35
Ether extract	2.75	2.71	3.52	3.43	3.31
Nitrogen-free extract	2.74	2.74	3.51	3.52	3.35

BODY WEIGHTS AND COST OF ASSIMILATED NUTRIENTS.

The data for the daily body weight of all the animals are reported in Table XII, and the observations noted by Dr. Thomas Clarke with chickens under like conditions of diet are presented for comparison. Our data and those of Doctor Clarke present the same tendency under

similar conditions of diet. The superiority of corn over oats seems to be beyond question. Szumowski⁹⁵ also found that exclusive corn feeding led to a marked increase in the body weight of fowls. Attention should be called to the fact that the corn test with chicken G and the oats trials with chickens F and H are exceptional, owing to the non-accessibility of sand to these subjects. In dietary experiments with poultry, the changes in body weight are often regarded as an index of the sufficiency of a ration, but such changes, to be of significance, must be observed in carefully checked experiments extended over a long period of time and with due regard to all possible sources of variation. Although the experimental periods of the present tests are of short duration, the uniform tendency of results, especially when correlated with the food assimilation, indicate that the differences in weight have an actual significance. With the single exception of chicken B, the same animals show a greater body weight on corn as compared with oats. Furthermore, the general tendency under the influence of the former grain is to increase in weight, while with the latter, the trend is in the opposite direction. It will be noted that the consumption of organic matter is much greater under the corn diet, not excepting the experiments with subject B. The assimilation of proteid in the last-named animal is slightly the greater in the corn trial. The marked inferiority of the wheat diet is demonstrated by the lower weight and tendency to loss as contrasted with the corn experiments on the same animals. Little may be said here as to the nature of the increase or loss of weight noted in these experiments. Under such circumstances the respiration calorimeter would be needed. In view of the fact that the animals were fully matured, growth of tissue would hardly be expected, and so the increased weight is quite likely referable to fat. Owing to the well-known fattening property of corn, considerable laying on of adipose tissue might be looked for under these conditions. On the other hand, the monotony of the single article of diet and the depressing effect of the confinement would tend to lower the ingestion of the grain and hence retard the increase in weight.

The importance of the relation of body weight to the cost of the diet is brought out in the data of Table X (Part V) and Table XI. The value of gain or loss in body weight has been assumed as equal to 1 cent per ounce. It should be pointed out that in the corn experiments the increase of body weight is slight, the grain practically furnishing a maintenance ration; for this reason it may be said to contain within itself approximately the proportions of a balanced ration. Of the corn tests, only those with chickens A and D show an actual profit, but as the tendency to increase in weight was manifest, it appears likely that the remaining animals would have yielded a profit after a longer period. The data for the oats experiments in each case evince a loss much greater than that referred to in any of the corn trials. In

the case of chicken B, the loss is much less on the corn diet, although a slight gain in body weight was observed in the oats test. The single wheat experiment is carried out at a marked loss.

THE USE OF THE GRAINS IN COMBINATION.

With reference to the use of the three grains in combined diet, the following suggestions appear warranted. Corn may be used to contribute a large proportion of any of the three nutrients, but more particularly of ether extract and nitrogen-free extract. The impression prevails among many poultrymen that the excessive or liberal feeding of corn is too fattening unless the animal is being specifically fed for that purpose. It is further thought that injurious effects are more especially apt to follow when the chicken is denied free ranging. Our observations do not corroborate this opinion, as no untoward results followed the exclusive use of corn. However, the nutritive ratio may be too wide, when egg production is the object in view.

Oats may be utilized for the crude proteid and fat, and probably will prove of most value when incorporated as a component of a narrow ration. This grain has been regarded by many feeders as being of special value for egg production owing to its high content of proteid. The digestibility of ground or hulled oats may be greater than that of the whole grain. The writer hopes to investigate this matter in the near future.

The lack of palatability of wheat would probably be greatly reduced or might be overcome in properly combined rations. Wheat may be introduced into the dietary for the crude proteid and nitrogen-free extract. The deficiency of fat in the wheat may be supplied by that of corn, and under the latter condition it is possible that the untoward effects of the ingestion of liberal quantities of wheat would be avoided.

The results here recorded may offer at least a partial explanation of apparent confusion of results in dietary experiments with certain so-called wide and narrow rations. Thus a diet of wide nutritive ratio may serve the purpose of a ration of narrow ratio with more satisfactory results than the latter itself. This apparently contradictory outcome indicates the fallacy of basing the digestibility on chemical composition. Thus the food containing the smaller quantity of proteid or fat has yielded larger quantities of the nutrients, owing to higher digestibility or palatability or both.

THE UTILIZATION OF SAND BY POULTRY.

Tables XIII and XIV present some notes on the consumption, retention, and excretion of sand by poultry. The consumption of sand, as we might, *a priori*, anticipate, is much greater on an oats than a corn diet. This is no doubt occasioned by the greater proportion of

fiber in oats. Tables VI and VII present the ratio of sand to the dry matter of the food given, and it will be seen that the data exhibit considerable fluctuation in the different experiments.

We have already referred to the digestion experiments with chickens F, G, and H under the condition of absence of sand from the diet. Chicken F was purchased February 26, and received no sand from that time to the day of the autopsy (March 13). The daily elimination of total SiO_2 was determined from time to time and showed a gradual decrease. Thus on March 2 the excretion of sand amounted to 0.7172 gram, while on March 3 and 12 the elimination was 0.6454 and 0.3300 gram, respectively. On March 13 the animal was killed and an autopsy performed. The viscera appeared perfectly normal. The gizzard and intestines were carefully opened and 2.84 grams of gravel removed. This was finely ground and the quantity soluble in dilute hydrochloric acid was found to be 4.97 per cent. Another animal from the same farm and used as a check on chicken F contained 3 grams of gravel in the crop, of which 3.1 per cent proved soluble in dilute hydrochloric acid.

Chickens G and H, purchased May 23, had no access to gravel throughout the period subsequently observed. On June 1 chicken G eliminated 0.1868 gram and chicken H 0.9633 gram of total SiO_2 . On June 21 the quantities excreted were 0.6462 and 0.4760 gram, respectively; on July 17 the daily excretion was reduced to 0.1064 gram and 0.1211 gram. Both of these animals at the end of the digestion experiments appeared in normal vigor and tone. Chicken G weighed 2 pounds 12½ ounces and chicken H 2 pounds 11½ ounces. The chickens were now fed oats exclusively, but ad libitum, and were deprived of sand from that date (July 23) to October 4, when they were again weighed. The weight was now 3 pounds 3 ounces and 3 pounds 1 ounce, respectively—a slight increase. The animals were a trifle less active than in July, but otherwise appeared normal. Apparently the lack of gravel had not led to any serious impairment of digestion. But after this the animals appeared gradually to become debilitated. On December 2 an attempt was made to photograph them with the collection pan attached, but they appeared unable to satisfactorily support the apparatus. The diet was now changed from oats to corn, and some improvement ensued in the general condition of the animals, which was more marked in the case of chicken G.

Subject H suddenly died on January 5. The autopsy revealed a serous-like exudate in and surrounding the crop, but the alimentary canal appeared otherwise normal. The macroscopic appearance of the other organs appeared normal. Considerable grain was noted in the crop and gizzard. The gizzard contained ten particles of gravel of varying size, the total weighing 0.767 gram. It is a remarkable fact that the chicken should have retained this material after a lapse exceed-

ing seven months. This observation is the more striking when correlated with the fact, noted by the writer, that the chickens may excrete as much as 6 grams daily under conditions of free access to gravel. Apparently there is a provision of nature whereby the chicken may to some extent retain the grinding material in the alimentary tract when it is not further available.

Chicken I was also placed under observation on May 23. This subject received no gravel and was fed on corn throughout the experiments. The absence of sand did not appear to occasion any decrease in the customary activity of the chicken. The figures in Table XIV show a considerable fall in the daily output between June 1 and 6. Following the latter date the daily output at the intervals adopted shows no striking variations, but excretion is maintained. It would seem, hypothetically, that after a sufficiently long period the silica of the gizzard would be completely eliminated.

We have already called attention to the impossibility of a determination of the proportion of assimilation of inorganic matter without the use of some artificial method for the separation of the outlet of urine and feces. There is a possible source of error which must not be lost sight of in such determinations, and that is in the possible content of the gravel of the gizzard in soluble inorganic matter. We have noted small fractions of such materials in our examinations. The subjects employed for digestion experiments may have consumed certain amounts of lime or iron salts in connection with the grit obtained about the farm, which will interfere with the accurate estimation of pure ash in the excrement. To avoid such confusion it seems desirable to keep the animals under observation for some time prior to the digestion experiment and with an abundance of sand at their disposal. In this way the gravel previously consumed may be largely or wholly gotten rid of.

A prominent feature of the data expressed in Table XIII is the lack of proportion between the ingestion and excretion of sand. Thus chicken A² consumed 31.92 grams of sand and chicken A³ 52.1 grams, but the difference in excretion between these two tests is slightly less than 3 grams. The consumption for chickens A³ and A⁴ is practically identical, but the output of SiO₂ is nearly 40 grams higher in experiment A³. In the cases of chickens C³ and B³ the consumption for C³ is over twice that for B², while the excretion for B³ is only one gram greater than that for C³. In the corn test with subject D the consumption of gravel is slightly greater than in the oats experiment with chicken E, but the excretion is far greater in the oats experiment. Differences were also noticed in experiments when sand was withheld from the fowls. Thus chickens F and H present a much higher output of sand than subject G.

BODY ANALYSES OF POULTRY AND OTHER ANIMALS.

It appears of interest to contrast the composition of the bodies of mammals with data obtained in the analyses of the bodies of poultry. Jordan⁹⁸ has reported a number of results obtained by Jenter with reference to the latter subject. Thus the mean data for the composition of Leghorn hens were: Water, 55.8 per cent; protein, 21.6 per cent; ash, 3.8 per cent; fat, 17 per cent. The dry matter of the eggs, exclusive of the shell, exhibited a close correspondence in composition to that of the body of the hen. A comparison with the figures for the analysis of a calf's body, made by Lawes and Gilbert,⁹⁹ shows that the proportionate crude proteid content is rather less than in poultry, while the fat content is slightly greater. As compared with a Berkshire pig,¹⁰⁰ the fowl contains a much lower percentage of fat and a larger proteid content. Data are available, published by Lawes and Gilbert,¹⁰¹ on the composition of increase when steers are fattening. While these data are not strictly comparable with those from poultry, they are of interest in showing a far greater content of fat and a much lower percentage of proteid than in the latter animals. The point seems to be suggested that the poultry tissues contain a relatively high proportion of proteid, while the fat content is rather lower than in some of the other farm animals. We have pointed out above that the fat utilization per unit body weight relative to the proteid and nitrogen-free extract is higher in poultry than in oxen, sheep, horses, cows, and hogs. It seems probable that in birds a proportionately greater quantity of the fat and carbohydrate is utilized for the maintenance of heat and energy than in the case of the other animals named.

BEARING OF PRESENT EXPERIMENTS ON CERTAIN DIETARY STUDIES.

It would be a matter of much interest to contrast the findings of the digestion trials of this paper with those of dietary experiments with poultry performed under similar conditions of feeding in the open air with abundant opportunity for exercise. In a review of the literature only one¹⁰² such experiment has been found in which a single grain was exclusively feed. The nearest approach to the comparison desired is to select those dietary experiments in which corn, oats, or wheat formed the major component of the diet and when the value of the grain in question for egg production or increase of weight was considered. It may be said at the outset that it seems highly desirable to investigate the digestibility of a large number of dietaries which have been used for various purposes in poultry feeding. In this way much confusion with regard to the results of such dietary experiments may be cleared up and the more exact rationale of the value of such diets be determined. Information of this character will prove of worth in the correction of existing dietaries and the formation of untried food combinations for special purposes.

There are a few observations on record which have to do with the comparative nutritive values of whole wheat and cracked corn. We have been unable, however, to locate experiments in which the end sought was a comparison of either of these two grains with oats. Smith and Brooks,¹⁰³ at the Michigan State Experiment Station, carried out comparative feeding trials with whole wheat and cracked corn. Each pen of chickens received lettuce, cabbage, rhubarb, oyster shell, and green bone in addition. One pen consumed 145.25 pounds of wheat and the other 159.5 pounds of cracked corn. It required 2.62 pounds of wheat as against 2.5 pounds of corn to produce 1 pound of gain in body weight; the results therefore slightly favored the corn ration. The chickens were limited in their range in order that the food consumption might be exactly known. In a later experiment Smith¹⁰⁴ noted that 2.8 pounds of wheat and 2.77 pounds of corn, respectively, were utilized to produce 1 pound gain in body weight, a result confirming the test just quoted. James Dryden,¹⁰⁵ at the Utah Station, has also studied the comparative value of rations in which corn and wheat formed the predominant constituents. The wheat seemed to yield superior results with reference to the egg production.

At the Cornell (N. Y.) State Experiment Station,¹⁰² the influence of the following rations was studied: The one designed to be of a wide nutritive ratio was composed of cracked Indian corn and Indian corn-meal dough; the one used as of narrow nutritive ratio consisted essentially of one part of a grain mixture and two parts of skimmed milk. The grain mixture was made up of equal parts of wheat bran, wheat shorts, and cotton-seed meal. The same quantity of green clover and cabbage was added to each lot. The chickens failed to develop satisfactorily with the corn diet. One prominent feature was the lack of growth of feathers. The bones of the chickens fed on the more nitrogenous ration were found to be 50 per cent stronger than those of the other lot and a larger number of eggs were yielded than on the diet of wider nutritive ratio. The eggs, however, were of poorer quality and smaller than those from the diet of wider ratio. In the present experiments with exclusive corn feeding a noticeable loss of feathers or a tendency to weakness of any of the bone structures was not observed. It might be true that under a longer period such symptoms would become manifest. It appears plausible, more especially in view of certain experiments (to be referred to later), that the deficiency of ash in the corn diet may have been concerned with the untoward results reported.

Brooks and Thomson,¹⁰⁶ of the Hatch Station of Massachusetts, have reported some interesting experiments which were planned to ascertain the effect of certain rations of narrow and wide ratio on both egg production and body weight and contrast the nutritive value of corn and wheat. In the ration of wide nutritive ratio corn figured as

the principal constituent, while wheat formed the main fraction of the more nitrogenous diet. The results demonstrated the overwhelmingly superior character of the corn ration. The components of the narrow ration were wheat, oats, millet, wheat bran, wheat middlings, gluten feed, animal meal, cut clover, rowen, and cabbage. The wide ration was compounded of whole corn, corn meal, wheat bran, animal meal, millet, rowen, and cut clover. Two breeds of fowls were employed, and the experiments were performed in both summer and winter. In both the seasons named, and with both breeds of chickens, the results were essentially the same; that is, the wide ration yielded superior results.

The production of eggs was 23 to 91 per cent higher on the corn as compared with the wheat ration. Further advantages of the ration with the wide nutritive ratio were a greater gain in weight and the earlier molting of the fowl. The cost of the food per egg was very much less than for the animals with the wheat rations, the palatability of which was much inferior to that of corn. These results seem rather opposed to the commonly accepted idea that the more nitrogenous ration is the more conducive to egg production, but this opinion is often based on the mere chemical composition of the ration without regard to the actual digestibility. Owing to the greater palatability of the corn ration, and the higher digestion coefficients as compared with oats and wheat, the actual assimilation of proteid matter was perhaps the higher in the ration of wide nutritive ratio. Hence, these results are in accord with the conclusions of the digestion experiments of the writer. The low proportion of ether extract yielded by wheat may be a factor in the inferior value of the wheat ration. In view of these considerations, the nutritive value of wheat for poultry seems to have been rather overestimated, and if this is definitely established it should prove of much economic importance.

In the experiments of Stewart and Atwood¹⁰⁷ on the influence of narrow and wide rations on egg production, the more nitrogenous ration differed from that of wide nutritive ratio in containing ground fresh meat and bone, but a smaller proportion of corn meal. The wide ration proved less efficient, while, as we have reported above, Brooks and Thomson obtained the reverse result. A plausible interpretation would be that more proteid was assimilated from the ground meat and fresh bone of the narrow ration than from the corn meal of the wide ration.

In the experiments of Wheeler¹⁰⁸ at the Geneva (N. Y.) Experiment Station with regard to the importance of sufficient quantities of inorganic matter in poultry foods, he first noted that a ration in which about two-fifths of the proteid was supplied by animal food proved much more profitable to chickens than another supplying an equal amount of proteid largely from vegetable sources, but supplemented

by skim-milk curd. When two such rations were fed to cockerels the results were decidedly favorable to the animal food, but the difference practically disappeared with the mature animals. The chief advantages of the animal ration were the more rapid growth and earlier maturity. The difference was even more pronounced with ducklings, as the growth was over three times as rapid under the diet in which one-fifth of the protein was of animal origin.

Further experiments¹⁰⁹ were conducted to ascertain the rationale of the inferiority of the ration consisting largely of vegetable food. It was suspected that the lower ash content of the vegetable diet was connected with this difference. When this deficiency was actually supplied by bone ash, the efficiency of the vegetable diet equaled or exceeded that from the animal source. Even for laying hens, the vegetable food, supplemented by bone ash, proved equally as satisfactory, at least for limited periods. Hence there appears to be no intrinsic practical difference in the digestibility of the animal and vegetable proteid matter; but the presence of the inorganic matter in proper proportion is essential in both cases. Wheeler, however, states that a diet containing a certain proportion of animal food is rather the more enduring in its effects than a ration composed of vegetable proteid alone, even when supplemented by bone ash to bring it to the highest point of efficiency.

These considerations suggest that the single grains employed in the present experiments lacked mineral matter, and that the digestibility might be heightened on repeating these tests with the addition of appropriate inorganic matter. Experiments directed to this end should prove of much practical value. Digestion tests should also be carried out between comparative rations of corresponding chemical composition, the one containing proteid largely of vegetable origin, and employing a wide variety of grains, the other comprising proteid from animal sources, as animal meal, fresh bone, etc.

SOME MISCELLANEOUS OBSERVATIONS.

THE RETENTION OF FOOD IN THE CROP.

The period of retention of grain in the crop of chickens may be expected to vary with the rate of the digestion processes as well as the amount of grain consumed. It is obviously a matter of practical importance to ascertain the degree of regularity of passage of the grain from the crop to the gizzard, and whether the rate of conveyance varies with the quantity of food ingested. It would seem plausible that the gizzard may possess a limited capacity to receive the grain within a given time. If this proves to be the case it becomes doubly essential to employ uniform amounts of daily food. In mammals, on the other hand, the food, even if consumed in irregular

daily amounts, becomes at once exposed on deglutition to the digestive juices.

Varying amounts of grain were fed to fowls with empty crops and the time occupied in the entire passage of the food to the gizzard carefully noted. The fowls, each weighing 3 pounds 5 ounces, received 30 grams of corn each at 10.45 a. m. At 9 p. m. both crops contained a few grains, but at 10.15 the organ of one fowl was empty, while that of the other still contained a few grains. At 11 p. m. the crop of the latter fowl became empty. At 8 a. m. both chickens again received 30 grams of corn each. Examination of the crop at 8 p. m. indicated that in both cases the crop contained a little material. At 9 p. m. the organ was empty in one of the chickens, and the other was found to be free from grain at 9.30. Thirty-five grams additional corn were fed at 10 p. m. and the crops became empty on the following day at 1 and 1.30 p. m., respectively. At 2 p. m. each fowl consumed 50 grams, and the time of the disappearance noted was on the following day at 2.15 and 2.25 p. m., respectively. These observations are typical of a large number made with several fowls. The period of retention of oats in the crop was also considered, with results essentially similar to those recorded above. As observed in the case of corn, a trifling variation was shown for fowls of equal weight.

In the digestion experiments with chickens G and H, the crop was examined each morning prior to feeding. As we have recorded above, the animals were fed twice daily, the afternoon meal being eaten at 4 and that of the morning at 9.30 o'clock. In chicken G, the crop was found free from corn in the morning except on two days. The crop of chicken H always contained a few grains of oats.

NOTES ON THE COMPOSITION OF THE EXCREMENT.

In the experiments about to be described it was planned to examine the excrement for certain constituents which have not as yet been reported, or whose presence needs confirmation. There is little literature bearing on the subject of the composition of avian urine, and the few observations on record are lacking in harmony. It is obvious that this matter would be greatly facilitated if the urine and feces could be obtained in a pure condition. The admixture of the two excretions must complicate the application of the various qualitative or quantitative methods adapted to mammalian urine.

While ammonium urate forms the chief component of the urine of the bird, it is not by any means the exclusive nitrogenous constituent. Reference has been made to Lang's¹¹ paper, in which he indicates that 12.50 to 18.60 per cent of the total urinary nitrogen of geese may be in the form of material exclusive of uric acid, urca, and ammonia, and quite likely represented by bodies of the amido-acid type. Due allowance must, of course, be made for the attendant abnormal experimental

conditions, as the large intestine was ligatured in order to obtain the urine in a pure condition.

The nitrogenous substances of birds' urine, aside from ammonium urate, are present in exceedingly small quantities. In fact it must be borne in mind that the creatinin, hippuric acid, purin bases, etc., are present in mammalian urine in relatively minute quantities, and this is conspicuously brought out when the amounts of such extractives are calculated per kilo body weight. Hence the urine of animals of so low a body weight as poultry would contain in all probability but minimal amounts of such extractives if present at all. In view of these considerations very large quantities of excrement would be required to demonstrate the presence of such bodies.

In 1861 Meissner⁸ devoted considerable attention to the composition of poultry urine. He examined the excrement for creatinin under conditions of both exclusive meat and grain diet. The excrement of the meat-fed hens readily yielded creatin but no creatinin. Only minute amounts were eliminated by the grain-fed animals, and in many cases its presence could not be satisfactorily demonstrated. A much smaller quantity of creatin was contained in the excrement of hens fed with liver as compared with those on the meat ration. When creatin was administered hypodermically it was practically all recovered as such in the excrement. It seems open to question whether the creatin found by Meissner did not represent transformed creatinin, as the process of manipulation may have caused the conversion of the latter into the former substance. A large part or all of the creatin may have originated directly from that present in the meat fed. It is of interest in this connection that Mallet¹¹⁰ has found that creatinin when administered to man is largely excreted unchanged, while creatin is excreted in the form of creatinin.

Meissner claimed to have identified urea in the excrement from both meat and grain feeding, the quantity as expected being much smaller on the latter diet. Minkowski¹⁰ confirmed Meissner's statement that the urine of fowls contains urea, and he estimated that from 2 to 4 per cent of the urinary nitrogen was present in this form. In Beilstein's¹¹¹ *Handbuch der Organischen Chemie* the writer found a statement that urea is absent from the excrement after a herbivorous diet. No reference is appended for this assertion and it is opposed by the results of our experiments, to be described later.

Meissner searched the excrement of the hen for hippuric acid with negative results. He then attempted to ascertain whether the ingestion of benzoyl compounds would induce the excretion of hippuric acid, as has been established for mammals. This substance was apparently not formed. There were excreted two other bodies, one containing nitrogen and the other nonnitrogenous, which are described, but their constitution was not determined.

Jaffé³² found that benzoyl compounds led to the formation of a nitrogenous body, apparently corresponding to the substance reported by Meissner. This body was designated ornithuric acid and is analogous in structure to hippuric acid, being a condensation product of benzoic acid and diamido-valerianic acid. He makes no mention as to the presence or absence of this body from the excrement of animals which had not received benzoyl compounds. The nonnitrogenous body referred to by Meissner is not mentioned in Jaffé's communication.

Bongers¹¹² also failed to detect hippuric acid in the excrement of fowls, and found that this body was excreted as such when administered per os or hypodermically. Sodium benzoate was observed to yield 60 per cent of its benzoic acid as such in the excrement, the remainder being largely transformed to ornithuric acid. Ornithuric acid could not be found in the excrement of the animals on a mixed diet which had received no benzoic acid. It is to be presumed that those foods which lead to a pronounced excretion of hippuric acid in mammals will induce the elimination of ornithuric acid in birds. Bongers claims that the feeding of gelatin plus sodium benzoate occasioned a very marked elimination of ornithuric acid, but no hippuric acid could be detected in the excrement. Apropos of the above considerations, it may be stated that a condensation product of pyromucic acid and glycocoll, analogous to hippuric acid, has also been found in the urine of hens. Jaffé and Cohn¹¹³ noted that furfural was transformed to pyromucic acid in hens, as Jaffé had previously pointed out in the case of dogs and rabbits. Part of the pyromucic acid was eliminated as such and part in the condensation form mentioned above.

The urine of hens, in addition to the substances already described, may contain purin bases in very minute quantity. Milroy²⁰ has reported this result from the examination of urine obtained under conditions of an artificial anus.

The writer has searched the literature for statements relative to the elimination of ethereal sulphuric acid. As has been previously indicated, owing to the rapidity of the digestion processes in birds and the ill-defined development of a large intestine, there is probably a relatively small extent of intestinal putrefaction; hence a relatively small elimination of indol, skatol, and bodies of that type might be expected. Christiani¹¹⁴ detected ethereal sulphuric acid in hens' urine after a meat diet and found that the ingestion of indol leads to its excretion in the form of indoxylsulphuric acid. Schary¹¹⁵ asserts that the subcutaneous injection of phenol results in the elimination of this body in the form of ethereal sulphuric acid. Peurosch¹¹⁶ claims that the subcutaneous injection of phenol or ligature of the intestine does not cause the appearance of indoxylsulphuric acid in the urine. On the authority of Bongers¹¹² benzol, when administered to hens, is oxidized, as in mam-

mals, to phenol, and leaves the kidneys as ethereal sulphuric acid. The negative influence of extirpation of liver on the metabolism of sulphur has been already referred to at a former place.³³ These few observations show that much additional investigation is required in this connection.

In our examination of the excrement we have kept the following ends in view: To search for the presence of urea, creatinin, hippuric acid, ornithuric acid, allantoin, kynurenic acid, benzoic acid, and cholesterin-like material. It need hardly be mentioned that we have borne in mind the possible presence of substances not heretofore described.

Urea.—Samples weighing 25 grams of both the dried ground corn and oats excrement were selected for this test. The urea content of these samples would in all probability be lower than in the freshly passed excrement, as the temperature of drying over the steam bath would tend to cause decomposition. The samples were treated with 500 c.c. of 95 per cent alcohol each, thoroughly stirred and filtered. The filtrate was evaporated to dryness over a water bath at 50° to 60° C. and the residue taken up in 25 c.c. of water. The method of Mörner and Sjöquist¹¹⁷ was now followed. The solution was treated with an equal volume of a saturated solution of barium chloride containing 5 per cent of barium hydrate. The precipitate was filtered off and the clear filtrate evaporated to dryness between 50° and 60° C. The residue was extracted with 25 c.c. of cold absolute alcohol and the filtrate allowed to spontaneously evaporate to dryness. The residue so obtained appeared partly crystalline and partly amorphous. The crystals were made up of fine, long needles closely resembling urea, and the application of the urea nitrate test resulted positively. Although no quantitative determination was attempted, it was seen that the amount present in the weight of excrement taken must be exceedingly small.

Hippuric acid.—Attention has already been called to the fact that the acetic-ether extracts of the excrement contain a small percentage of nitrogen which might possibly be referable to hippuric acid. Twenty grams of mixed corn and oats excrement were employed in this test. This material had been used for the quantitative determinations of ether extract, and hence was entirely freed from fat. The substance was now extracted in the cold with two successive portions of 100 c. c. of acetic ether, and the combined filtrates of a deep orange color were distilled until the volume was reduced to 25 c. c. This residual fluid was allowed to gradually concentrate at room temperature in a large open dish. The slight residue appeared entirely amorphous. It was redissolved and again allowed to concentrate with similar result.

Another procedure was attempted with the use of larger quantities of excrement. Two 50-gram portions from corn, oats, and wheat feeding, respectively, were treated as follows: Extraction was first carried out with 600 c. c. of water, the material being stirred frequently for three hours. A few drops of a thymol solution were added to prevent putrefaction, and filtration was undertaken. This was twice repeated in order that a perfectly clear fluid might be obtained. The filtrates from the two samples were now combined and evaporated to a volume of about 200 c. c. The fluid was allowed to stand in the ice box several days. Considerable material separated out of solution, which was collected on a filter and washed with a little water. This material was preserved for future examination. The filtrate from the washings was evaporated to a thick sirupy consistency of blackish appearance. This residue was thoroughly extracted with ether, and finally with boiling 95 per cent alcohol. The latter extract was filtered and evaporated to a volume of 25 c. c., covered, and left to stand at room temperature. Considerable amorphous organic matter separated, but at the end of two weeks no substance of a crystalline character could be demonstrated. The fluid was permitted gradually to evaporate to dryness, and was examined from time to time. The residue was found to consist largely of inorganic matter. A few crystals were noted resembling urea, but the amount was too small to permit of identification. Hippuric acid, if present, would seem to be in inappreciable amounts. Creatinin was looked for in this residue, but no crystals conforming to the crystalline character of that body were recognized. The residue was redissolved in 25 c. c. of 95 per cent alcohol, 5 c. c. of 10 per cent ZnCl_2 solution added, and the fluid being covered was left to stand for the possible formation of creatinin ZnCl_2 crystals. After standing for a space of four weeks it was examined microscopically, but no crystals were detected.

The material which had separated from the aqueous extract was now submitted to an examination. It contained a large proportion of inorganic matter, and the organic fraction seemed to be largely composed of uric acid or urates. Extraction was performed with 100 c. c. of 95 per cent alcohol, and the filtrate having evaporated to 25 c. c. was allowed to concentrate spontaneously to dryness. The residue was found to consist mostly of inorganic matter and contained a few hexagonal crystals not of the appearance of hippuric acid. The quantity was insufficient for identification.

Another plan was executed as follows: The aqueous extract of 50 grams of excrement prepared as described above was concentrated to a volume of 200 c. c. and allowed to cool. Filtration was then conducted and the filtrate slightly acidified with sulphuric acid. This extract was repeatedly shaken with acetic ether and the combined extracts distilled to a small volume and permitted to evaporate to dry-

ness at room temperature. The residue obtained was of slight amount and was found to be entirely amorphous. The material was redissolved in 25 c. c. of acetic ether and the solution permitted to concentrate to dryness in a refrigerator. Despite this very gradual evaporation the same result was obtained.

In carrying out a further experiment 50 grams of the dry and finely divided excrement were placed in a paper coil and subjected to constant extraction with hot 95 per cent alcohol under a reflex condenser. This process was continued until no additional pigment was removed from the material. The extract was then concentrated to the condition of a thick sirupy liquid and until no further odor of alcohol could be appreciated. The residue was now twice extracted with boiling ether for the removal of fat. The ether-extracted material was covered with 50 c. c. of 95 per cent alcohol and warmed. It was filtered, sulphuric acid was added to very slight excess and the fluid was left to concentrate gradually at room temperature. A separation of amorphous material appeared, which increased with the decrease in volume. The separated substance was repeatedly examined for crystalline material, but with negative results. The dry residue was treated with three successive 25 c. c. portions of acetic ether. These combined extracts were distilled to a volume of 25 c. c. and the residual fluid left to evaporate. The slight amount of residue obtained failed to show any crystals of hippuric acid. Hence our examinations confirm the statements of Jaffé and Bongers, that the excrement of the fowl contains no hippuric acid.

Ornithuric acid.—Jaffé's method, a little modified, was applied to several 50-gram samples of the grain excrement, as follows: Constant extraction with hot 95 per cent alcohol was carried out in a paper coil for five hours. The alcohol was distilled from the extract and fat removed from the residue by means of ether. The next procedure consisted in extracting the residue with 100 c. c. of boiling absolute alcohol, a small fraction of the material resisting solution. This was collected on a small filter, the filtrate placed on the steam bath, and the alcohol driven off. The residual material was stirred in 50 c. c. of water and slightly acidified with sulphuric acid. Extraction with three successive 50 c. c. portions of ether was performed and the combined extracts distilled to small volume. On gradual evaporation of the residual ether there remained behind an amorphous residue in small quantity. Jaffé noted ornithuric acid in such an ethereal extract. The fluid exhausted by ether was covered and left to stand in a refrigerator for the possible deposition of ornithuric acid. After an interval of six weeks microscopic examination failed to reveal the presence of any crystalline material. Two weeks later a few needle-like crystals were noted, but the quantity was too slight to permit of purification or the application of any tests. Two weeks later still, the

amount was unchanged. Several examinations of the character just recorded gave uniformly negative results. Ornithuric acid appears to be excreted only after a diet containing certain benzoyl compounds.

Benzoic acid.—During the course of the examination of a large quantity of ether extract from the excrement, an odor strongly suggesting the oil of bitter almonds was noted. The odor, however, disappeared on standing over night. No benzoic acid could be demonstrated in the ether extract. Fifty grams of finely ground excrement were covered with 300 c. c. of water, acidified slightly with hydrochloric acid. Distillation with steam was now undertaken until 200 c. c. of fluid had passed over. The distillate presented a film of fatty-like material on the surface, in all probability fatty acid. The solution was shaken several times with ether and the combined extracts evaporated to dryness at ordinary temperature. The slight residue obtained displayed no evidence of benzoic acid.

Creatinin.—Reference is made on page 82 to a negative attempt to demonstrate the presence of creatinin. Another procedure was carried out. Fifty grams of material were continuously extracted with hot 95 per cent alcohol for five hours. The extract having been heated over the steam bath to remove the alcohol, the residue was treated with ether to remove fat, and the ethereal extract was filtered off. The residue remained largely insoluble on being rubbed up in 50 c. c. of boiling water. Filtration was conducted and one-half cubic centimeter of an acid-free 30 per cent solution of $ZnCl_2$ was added to the clear filtrate. The preparation was examined from time to time for the possible formation of crystals of creatinin zinc chloride. After standing in the refrigerator for a period of two months there was no indication of a crystalline formation, although a small amount of amorphous material had precipitated. Two further examinations with 50-gram samples of grain excrement were carried out, using the same method, but no evidence of the presence of creatinin could be obtained with the amounts of material employed. If present, its content must be extremely small.

Allantoin.—In view of a number of considerations the presence of allantoin in the urine of the bird would not seem unexpected. Thus, there is a close chemical relationship between this body and uric acid, for the oxidation of uric acid with potassium permanganate under appropriate conditions leads to the production of allantoin. Then the appearance of allantoin in the urine of the dog or cat is associated with conditions of diet when the output of uric acid is greatly augmented. Thus Minkowski¹⁷ demonstrated a ready production of allantoin in dogs on feeding thymus gland, which enormously increases uric acid elimination, and Salkowski¹¹⁸ reported a similar observation on administering large amounts of pancreas. The writer¹¹⁹ found that similar results hold true for the cat. The ingestion of uric acid as

such led to a pronounced excretion of allantoin in both these classes of animals. These observations, taken collectively, strongly point to the conclusion that allantoin represents an intermediate stage in the physiological oxidation of uric acid to urea.

Allantoin is readily soluble in hot 95 per cent alcohol, but less so in absolute alcohol. In ether it is practically insoluble. It gradually separates in characteristic crystalline form from an alcohol solution on standing. Hot water dissolves it readily, cold water with difficulty. In view of its solubility in hot alcohol the writer looked for the separation of this body from the alcoholic extracts of the grain excrement prepared in connection with the examination for hippuric acid and creatinin, but under those circumstances was unable to detect it. A further endeavor was made to locate this substance. Two samples of excrement, weighing 50 grams each, were rendered fat-free in a continuous extraction apparatus. The two lots of material were then submitted to constant extraction with hot 95 per cent alcohol for five hours. The two alcoholic extracts were united, distilled until reduced to a volume of about 100 c. c., and then exposed to the air to provide for gradual evaporation. A precipitation of amorphous material occurred, but no crystalline substance could be detected. The residue was extracted with absolute alcohol, the insoluble portion filtered off, and the clear filtrate left to stand. The gradual separation of amorphous matter again occurred, and frequent microscopic examinations failed to reveal the presence of any crystalline separation. The dry residue in all probability contains urea crystals, and it is possible that the large quantity of dark amorphous material present would obscure the appearance of a small quantity. This residue was extracted with petroleum ether, and, on evaporation of the reagent, a few long needle-like crystals were deposited. The quantity was not sufficiently large to establish their identity. In view of these apparently negative results it would be of interest to inquire regarding the possible production of allantoin after feeding nuclein-rich foods to fowls.

Kynurenic acid.—The writer also considered the possibility of kynurenic acid excretion by fowls. Among mammals this substance seems to be limited to the urine of dogs, and is closely associated with the metabolism of proteid matter.¹³ It is of additional interest from the fact that, aside from a certain constituent of the urine of the skunk, it is the only quinoline derivative reported as normally found in the urine of mammals. It appeared of interest to ascertain whether birds excrete this substance. With this end in view the following procedure was carried out: Fifty grams of the ground grain excrement were extracted with 400 c. c. of cold water. The aqueous infusion was filtered, evaporated to a volume of about 100 c. c., permitted to cool, and repeatedly filtered until clear. Jaffé's bromine test was repeatedly applied, but no bromine precipitate resulted. Search was also made

for this body by the use of Capaldi's¹²⁰ method. Twenty-five grams of the material were thoroughly stirred with 300 c. c. of 50 per cent ammonia. The filtered ammoniacal extract was treated with sufficient barium chloride to make the solution of 10 per cent strength. The mixture was filtered and the filtrate made acid with hydrochloric acid. Kynurenic acid, if present, should be deposited after standing from sixteen to twenty-four hours. A mere trace of amorphous material separated, and no change ensued on standing for a period of two weeks. This result was confirmed by a second trial, when a larger amount of excrement was employed. Kynurenic acid, then, would seem to be absent from the excrement.

Cholesterin-like material.—In the endeavor to demonstrate the presence of cholesterin-like material in the excrement, the ether extract of 50 grams of finely divided dung from the grain experiment was transferred to a small beaker and carefully saponified over the water bath with an alcoholic potash solution. The alcohol was gradually driven off and the residue taken up with 150 c. c. of water. The solution was transferred to a separatory funnel and thoroughly shaken with ether, a few drops of alcohol being added to facilitate the separation of the ether. This ethereal extraction was twice repeated and the combined extracts distilled until reduced to a volume of 25 c. c. Evaporation to dryness was then allowed to proceed in a refrigerator. A large crop of crystals was obtained, which, on microscopic examination, proved to be largely made up of flat, six-sided plates. No crystals of the notched appearance so characteristic of true cholesterin were noted. A few clusters of delicate needles were also scattered about. The material was then dissolved in absolute alcohol and the substance recrystallized from this medium. The crystals in this case presented the same general appearance as in the ethereal residue. The reaction of Salkowski was now applied and a positive result obtained. The two forms of crystals observed in the ether extract of the saponification mixture suggest the presence of different types of cholesterin.

The excrement from pure meat feeding was also examined for cholesterin-like material. One hundred grams of finely chopped ground substance were extracted with cold ether, the ethereal extract distilled off, the residue saponified and treated as described above for the grain excrement. A considerable quantity of crystalline material was obtained, which was twice purified. The crystals presented the appearance of minute six-sided plates, but none of needle-shaped form could be detected. The Salkowski test was readily obtained. By analogy from its presence in mammals this cholesterin-like substance is probably derived from the bile. The corresponding material obtained from the grain excrement is presumably to be ascribed to the food and bile, as corn and oats contain a form of cholesterin which is designated as phytosterin. The quantitative estimation of the cholesterin of the excrement is desirable with a view to its cor-

rective application in the determination of fat, a matter which we have referred to on page 41.

An amorphous organic alcohol-soluble substance.—It was observed that the alcoholic extracts of the excrement contained a large amount of amorphous material. The great bulk of it separated in the form of minute globules seemingly of uniform appearance. A sufficient quantity for manipulation was collected and examined. It dissolved readily in the alkali hydrates and ammonia, from which solutions it was precipitated in flocculent condition by mineral or acetic acids. It appeared to be insoluble in ether, benzol, chloroform, and water. The addition of water or ether to the alcoholic solution precipitated the substance in finely divided condition. Absolute alcohol takes it into solution, but much less readily than the same reagent of 95 per cent strength. The material is not hygroscopic, but dries readily in the open air and may be ground to a powder. It holds its pigment tenaciously and we have found no means as yet to remove a sufficient amount of it. Animal charcoal proved ineffective, and ether, benzol, and chloroform were unavailing. Purification of the material was attempted by repeated solution in ammonia, filtration and precipitation by the addition of hydrochloric acid. An analysis for nitrogen yielded a content of 10.41 per cent. None of the proteid color tests could be applied to the substance, owing to the large amount of associated pigment. The fact of the solubility of the material in alcohol excludes it from the class of albumins, globulins, or nucleins. It corresponds most closely to the class of proteid bodies found in corn and oats known as the zeins.

Chittenden and Osborn⁶⁵ report this body as soluble in alcohol of 61 to 91 per cent strength and containing 16.13 per cent nitrogen. While the content of nitrogen is much lower in the writer's preparation, it must be remembered that it is much more difficult to obtain the pure material from the excrement than from the grain, and some chemical changes may have occurred in its passage through the alimentary tract.

It should be noted in this connection that Szumowski⁶⁶ has recently made some additional observations on the chemico-physiological properties of zein. He claims that the substance is insoluble in absolute alcohol, whereas the preparation described by us is quite soluble in this reagent. Associated impurity or chemical change in digestion may be partially accountable for this difference.

We have referred at a former place to his studies relative to the peptic and tryptic digestion of zein. We have applied digestion tests to this alcohol-soluble body. One-half gram of the substance was treated with 50 c. c. of 0.2 per cent HCl containing 1 per cent of active Merck pepsin. At the end of a digestion period of forty-eight hours at 38° to 40° C. the amount of insoluble material seemed unchanged. A slight quantity of pigment had entered solution. The

filtrate from this fluid was treated with an equal volume of 95 per cent alcohol. A small amount of precipitate resulted, which was filtered off and tested with Millon's reagent with a positive result. This may be attributed, at least in part, to the trace of proteid associated with the pepsin preparation. The digestion was continued for one week with apparently little or no change in the quantity of the substance being acted upon. The filtrate was treated with 95 per cent alcohol as before, with a resultant precipitate rather larger than observed for the first digestion fluid. It responded to both the biuret and Millon's tests. It is planned to further examine this substance in the near future.

Further experiments on the digestibility of poultry foodstuffs are now in progress.

SUMMARY.

The provisional conclusions arrived at by these experiments may be presented as follows, it being recalled that but one experiment was completed with wheat:

(1) Corn, oats, and wheat show marked differences in the digestibility of several of their respective nutrients.

(2) The crude proteid and nitrogen-free extract are assimilated in much greater proportion in corn than in oats. The digestion coefficient for the crude proteid of wheat is intermediate in value between the average results for these two grains.

(3) The availability of the crude fat of corn is slightly greater than that of oats.

(4) The digestibility of the crude fat of wheat is conspicuously less than that of corn and oats; this fact may at least in part account for the untoward results of a sole wheat diet.

(5) Chickens consume a much greater quantity of corn than oats—an important fact to be kept in mind in a comparison of the digestion coefficients of the two grains.

(6) The nutritive superiority of corn over oats is indicated by the body weight. An increase is manifested under the use of corn while a tendency in the opposite direction is seen with oats.

(7) The nutrients of corn are fed at a lower cost than those of oats and wheat. The last-named grain is the most costly of the three foods. This conclusion is based on the actual availability of the various nutrients of the grains.

(8) Regarding the application of these grains in mixed dietaries the following suggestions are offered: Corn may be included for the main nutrients, that is, crude proteid, nitrogen-free extract, and ether extract. Oats may be utilized for the crude proteid and ether extract. Wheat may be employed for the crude proteid and nitrogen-free extract, but adequate provision must be made for the deficient yield of this grain in fat.

(9) The proteid and fat of beef show high coefficients of digestibility, the former is considerably higher, the latter but slightly less than the corresponding nutrients in corn.

TABLE I.—*General scheme of the experiments.*

Chicken.	Total air-dried food consumed.		Total air-dried excrement voided.	Total water consumed.	Total sand consumed.	Duration of experiment.	
	Kind of food.	Weight.				Preliminary period.	Collection period.
		Grams.	Grams.	Grams.	Grams.	Days.	Days.
A ¹	Corn	1,294.00	197.30	985	8.60	6	13
B ¹	...do...	437.38	77.78	599	(a)	5	6
C ¹	...do...	491.82	86.04	398	(a)	5	6
D	...do...	775.53	144.88	720	23.09	7	8
G	...do...	447.50	70.25	563	None.	7	9
A ²	Oats	633.62	304.69	1,056	31.92	5	11
A ³	...do...	421.48	218.19	757	52.10	8	8
B ²	...do...	542.71	246.98	828	31.50	5	9
C ²	...do...	337.42	169.32	563	(a)	5	8
C ³	...do...	306.20	157.33	446	64.38	6	7
E	...do...	394.85	189.05	615	27.44	6	8
F	...do...	219.59	91.45	339	None.	5	8
H	...do...	344.70	142.00	462	None.	6	9
A ⁴	Wheat	469.55	110.78	722	52.10	5	8
M	Meat	300.00	50.25	253	None.	5	6
N	...do...	300.00	51.30	265	None.	5	6

a Amount not noted.

TABLE II.—*Daily consumption of food and water, weight of excrement, and body weight.*

	Corn, chicken A ¹ . (Duration, Nov. 22-Dec. 4, inclusive.)				Corn, chicken B ¹ . (Duration, Dec. 19-24, inclusive.)				Corn, chicken C ¹ . (Duration, Dec. 21-26, inclusive.)			
	Air-dried food consumed.	Air-dried excrement.	Water consumed.	Body weight.	Air-dried food consumed.	Air-dried excrement.	Water consumed.	Body weight.	Air-dried food consumed.	Air-dried excrement.	Water consumed.	Body weight.
	Gms.	Gms.	c. c.	Lbs. oz.	Gms.	Gms.	c. c.	Lbs. oz.	Gms.	Gms.	c. c.	Lbs. oz.
First day	161	16.2	68	3 6	74.5	14.0	55	3 1	80.0	20.5	40	3 15
Second day	162	19.7	69	3 8	72.3	13.2	82	3 1	76.2	12.7	64	3 14½
Third day	126	12.1	69	3 8½	69.9	17.9	66	3 ½	82.1	15.5	57	3 14½
Fourth day	110	18.8	78	3 9	70.7	11.6	63	3 ½	83.9	13.3	62	3 14
Fifth day	132	25.4	69	3 9½	75.0	11.2	79	3 1	83.9	13.6	57	3 14½
Sixth day	123	18.9	71	3 9½	75.0	10.5	62	3 1½	85.7	11.2	62	3 14½
Seventh day	100	14.9	112	3 10	.....	.....	.....	.....	.....	.....	.....	.....
Eighth day	92	15.9	90	3 12½	.....	.....	.....	.....	.....	.....	.....	.....
Ninth day	68	15.5	82	3 12½	.....	.....	.....	.....	.....	.....	.....	.....
Tenth day	57	15.5	80	3 12½	.....	.....	.....	.....	.....	.....	.....	.....
Eleventh day	55	9.3	65	3 13	.....	.....	.....	.....	.....	.....	.....	.....
Twelfth day	53	12.1	60	3 13½	.....	.....	.....	.....	.....	.....	.....	.....
Thirteenth day	55	9.3	57	3 13½	.....	.....	.....	.....	.....	.....	.....	.....

TABLE II.—Daily consumption of food and water, weight of excrement, etc.—Continued.

	Corn, chicken D. (Duration, June 21-28, inclusive.)				Corn, chicken G. (Duration, July 15-23, in- clusive.)				Wheat, chicken A ⁴ . (Duration, Jan. 6-13, in- clusive.)			
	Air-dried food consumed.	Air-dried ex- crement.	Water con- sumed.	Body weight.	Air-dried food consumed.	Air-dried ex- crement.	Water con- sumed.	Body weight.	Air-dried food consumed.	Air-dried ex- crement.	Water con- sumed.	Body weight.
	Gms.	Gms.	c. c.	Lbs. oz.	Gms.	Gms.	c. c.	Lbs. oz.	Gms.	Gms.	c. c.	Lbs. oz.
First day.....	90.6	18.6	80	4 2½	49.8	7.6	77	2 13½	56.1	12.8	102	3 9½
Second day.....	85.4	20.3	80	4 2½	49.1	7.9	55	2 13	58.1	14.2	90	3 9½
Third day.....	100.1	22.3	81	4 3	50.0	5.9	45	2 13	59.3	17.6	97	3 9
Fourth day.....	99.4	17.7	78	4 3	50.0	8.1	37	2 13	60.1	20.2	98	3 9
Fifth day.....	100.3	18.8	82	4 5	50.0	7.4	82	2 13	58.6	14.9	97	3 8½
Sixth day.....	99.9	18.0	84	4 5	49.2	8.9	54	2 12½	59.6	16.8	82	3 9½
Seventh day.....	100.3	19.9	68	4 6	50.0	7.5	57	2 12½	58.9	10.3	81	3 9
Eighth day.....	99.5	20.9	79	4 6	49.4	6.5	47	2 12½	59.1	11.2	75	3 8½
Ninth day.....					50.0	8.2	57	2 12½				

	Oats, chicken A ² . (Duration, Dec. 17-27, in- clusive.)				Oats, chicken C ² . (Duration, Jan. 5-12, in- clusive.)				Oats, chicken C ³ . (Duration, Jan. 19-25, in- clusive.)			
	Air-dried food consumed.	Air-dried ex- crement.	Water con- sumed.	Body weight.	Air-dried food consumed.	Air-dried ex- crement.	Water con- sumed.	Body weight.	Air-dried food consumed.	Air-dried ex- crement.	Water con- sumed.	Body weight.
	Gms.	Gms.	c. c.	Lbs. oz.	Gms.	Gms.	c. c.	Lbs. oz.	Gms.	Gms.	c. c.	Lbs. oz.
First day.....	50.0	23.4	68	3 9½	40.0	23.3	69	3 10	42.2	18.5	52	3 8
Second day.....	54.0	23.5	75	3 10	40.5	18.3	71	3 10½	43.6	23.0	57	3 5
Third day.....	67.0	23.0	92	3 11	45.6	26.0	64	3 9	43.6	22.3	62	3 5
Fourth day.....	11.0	21.1	78	3 10	42.8	18.5	64	3 9	45.2	21.8	63	3 5
Fifth day.....	43.0	19.1	68	3 10	42.7	22.3	63	3 8½	45.8	17.2	62	3 5
Sixth day.....	70.7	23.3	92	3 10½	40.7	19.7	62	3 9	45.1	22.7	65	3 5
Seventh day.....	78.5	34.9	110	3 11	41.9	20.5	62	3 8½	40.7	21.2	60	3 5½
Eighth day.....	62.6	29.6	100	3 9½	43.2	20.1	50	3 8				
Ninth day.....	50.3	30.7	104	3 9½								
Tenth day.....	64.5	25.4	107	3 9½								
Eleventh day.....	52.0	22.3	110	3 9½								

TABLE II.—Daily consumption of food and water, weight of excrement, etc.—Continued.

	Oats, chicken B ² . (Duration, Jan. 4-12, inclusive.)				Oats, chicken E. (Duration, Mar. 4-11, inclusive.)				Oats, chicken F. (Duration, Mar. 4-11, inclusive.)			
	Air-dried food consumed.	Air-dried excrement.	Water consumed.	Body weight.	Air-dried food consumed.	Air-dried excrement.	Water consumed.	Body weight.	Air-dried food consumed.	Air-dried excrement.	Water consumed.	Body weight.
	Gms.	Gms.	c. c.	Lbs. oz.	Gms.	Gms.	c. c.	Lbs. oz.	Gms.	Gms.	c. c.	Lbs. oz.
First day.....	60.0	26.8	118	3 3	49.4	24.0	82	3 7	31.3	11.8	58	2 3½
Second day.....	60.0	30.5	66	3 2½	49.4	23.9	76	3 7½	28.7	11.3	54	2 3½
Third day.....	60.0	29.4	92	3 2½	49.9	25.6	81	3 6½	30.0	12.5	53	2 3½
Fourth day.....	60.6	26.5	100	3 2½	48.9	22.8	88	3 6	32.5	13.4	55	2 2½
Fifth day.....	60.0	30.1	92	3 3	49.3	24.0	73	3 6½	28.8	12.5	49	2 2½
Sixth day.....	60.6	34.5	96	3 2½	49.5	26.0	82	3 6½	21.8	12.1	80	2 1½
Seventh day.....	60.6	31.9	81	3 3	49.3	21.0	65	3 5	23.6	12.2	40	2 1
Eighth day.....	60.3	29.8	66	3 3½	49.0	30.8	68	3 5	22.9	10.6	42	2 ½
Ninth day.....	60.6	34.3	82	3 3½								

	Oats, chicken A ² . (Duration, Dec. 29-Jan. 5, inclusive.)				Oats, chicken H. (Duration, July 15-23, inclusive.)			
	Air-dried food consumed.	Air-dried excrement.	Water consumed.	Body weight.	Air-dried food consumed.	Air-dried excrement.	Water consumed.	Body weight.
	Gms.	Gms.	c. c.	Lbs. oz.	Gms.	Gms.	c. c.	Lbs. oz.
First day.....	54.6	23.2	102	3 9	36.0	12.1	64	3 3½
Second day.....	52.8	15.1	90	3 9	35.1	14.6	44	3 2
Third day.....	54.1	28.9	97	3 8½	38.2	19.4	56	3 3
Fourth day.....	54.2	31.7	98	3 8½	39.5	15.1	35	3 2½
Fifth day.....	54.5	31.5	97	3 8½	39.0	14.6	50	3 2
Sixth day.....	54.4	24.0	82	3 8	38.8	18.0	57	3 2
Seventh day.....	49.8	30.9	81	3 8	39.4	14.6	47	3 1
Eighth day.....	46.9	26.7	75	3 7½	39.3	16.6	57	3 1
Ninth day.....					39.4	18.4	52	3 ½

	Beef, chicken M. (Duration, Apr. 15-20, inclusive.)				Beef, chicken N. (Duration, Apr. 15-20, inclusive.)			
	Fresh beef consumed.	Air-dried excrement.	Water consumed.	Body weight.	Fresh beef consumed.	Air-dried excrement.	Water consumed.	Body weight.
	Gms.	Gms.	c. c.	Lbs. oz.	Gms.	Gms.	c. c.	Lbs. oz.
First day.....	25	8.8	42	3 5	25	8.0	52	3 7
Second day.....	25	13.0	43	3 4½	25	8.7	43	3 7
Third day.....	25	8.0	43	3 4	25	7.9	46	3 6½
Fourth day.....	25	6.8	48	3 3	25	8.7	39	3 6
Fifth day.....	25	8.7	37	3 5½	25	9.4	44	3 5½
Sixth day.....	25	6.5	40	3 5½	25	9.0	41	3 5½

TABLE III.—*Composition of the food.*

AIR-DRIED.

	Corn.		Wheat.	Oats.		Meat.
	Sample 1.	Sample 2.		Sample 1.	Sample 2.	
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Moisture	11.33	11.14	9.53	8.29	9.12	<i>a</i> 7.06
Crude proteid.....	9.80	9.44	11.34	12.03	14.90	79.25
Crude fiber.....	2.05	2.16	1.59	10.25	9.75	.....
Ether extract.....	5.15	5.24	2.05	4.69	3.71	4.72
Ash.....	1.32	1.30	1.84	3.10	3.55	3.11
Nitrogen-free extract.....	70.35	70.72	73.65	61.64	58.97	.....
Starch.....	60.06	60.18	55.83	37.05	.....	.....
Sucrose.....	1.17	1.72	2.71	1.54	.....	.....
Dextrose.....	1.07	.86	.76	1.43	.....	.....
Pentosans.....	5.35	5.96	7.64	13.47	.....	.....
Total nitrogen.....	1.57	1.51	1.81	1.92	2.38	12.87
Peptone nitrogen.....	.....	.....	.....	.....	.....	.17
Nitrogen of meat-bases and gelatinoids.....	.....	.....	.....	.....	.....	.19
Organic matter.....	.....	.....	.....	.....	.....	96.89

WATER-FREE.

Crude proteid.....	11.05	10.62	12.53	13.11	16.40	85.27
Crude fiber.....	2.31	2.43	1.76	11.18	10.73	.....
Ether extract.....	5.81	5.89	2.26	5.11	4.08	5.08
Ash.....	1.49	1.46	2.03	3.38	3.91	3.34
Nitrogen-free extract.....	79.34	79.58	81.41	67.21	64.89	.....
Starch.....	67.74	67.72	61.71	40.39	.....	.....
Sucrose.....	1.32	1.93	2.99	1.68	.....	.....
Dextrose.....	1.21	.97	.84	1.56	.....	.....
Pentosans.....	6.03	6.71	8.44	14.69	.....	.....
Total nitrogen.....	1.77	1.70	2.00	2.09	2.62	13.84
Peptone nitrogen.....	.....	.....	.....	.....	.....	.18
Nitrogen of meat-bases and gelatinoids.....	.....	.....	.....	.....	.....	.20
Organic matter.....	.....	.....	.....	.....	.....	96.66

^aThe moisture of the pressed meat fed was 66.56 per cent.

TABLE IV.—Composition of the excrement (air-dried).

	Corn. Chicken A ¹ .	Corn. Chicken B ¹ .	Corn. Chicken C ¹ .	Corn. Chicken D.	Corn. Chicken G.	Wheat. Chicken A ⁴ .	Oats. Chicken A ² .	Oats. Chicken A ³ .
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Moisture	4.04	3.75	4.70	6.02	7.09	4.17	5.25	3.69
Total nitrogen	6.12	6.72	7.62	4.74	6.64	6.12	3.42	3.12
Uric acid nitrogen ..	3.50	4.50	4.72	2.78	3.59	3.73	1.79	1.80
Ammonia nitrogen ..	.96	1.04	1.13	.94	1.33	.65	.53	.48
Crude proteid	10.37	7.37	11.06	6.37	10.75	10.87	6.87	5.25
Ether extract	4.79	3.89	4.10	3.60	6.34	3.58	1.76	1.60
Crude fiber	11.16	9.20	8.83	10.40	13.66	11.23	18.92	18.51
Total ash	11.16	14.46	8.70	23.07	8.10	23.48	19.31	29.20
N.-free extract	46.80	46.56	47.07	41.05	41.66	34.67	41.88	35.76
Pentosans	20.47		26.23	20.96			20.52	21.95
Uric acid	10.52	13.51	14.17	8.35	10.79	11.21	5.37	5.41
Ammonia	1.16	1.26	1.37	1.14	1.61	.79	.64	.58
Pure ash	7.40	6.65	3.48	12.99	7.53	15.93	4.46	7.09
Total SiO ₂	3.76	7.81	5.22	10.08	.57	7.55	14.85	22.11

	Oats. Chicken B ² .	Oats. Chicken C ² .	Oats. Chicken C ³ .	Oats. Chicken E.	Oats. Chicken F.	Oats. Chicken H.	Meat. Chicken M.	Meat. Chicken N.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Moisture	4.76	3.91	3.24	3.83	5.02	6.71	3.18	2.71
Total nitrogen	3.91	3.89	3.49	4.35	5.54	6.13	26.09	26.37
Uric acid nitrogen ..	2.26	2.23	2.21	2.60	3.33	3.45	18.97	19.33
Ammonia nitrogen ..	.56	.54	.55	.65	.72	1.01	2.31	2.40
"Residual" nonpro- teid nitrogen							2.06	2.11
Crude proteid	6.81	7.00	4.56	6.87	9.31	10.43	17.18	15.81
Ether extract	2.12	2.13	1.33	1.63	2.10	1.74	1.36	1.39
Crude fiber	20.31	18.25	18.20	20.50	23.38	21.52		
Total ash	24.66	18.59	33.22	21.27	7.72	8.83		
N.-free extract	33.87	42.77	32.13	37.31	41.60	39.19		
Pentosans	24.11	25.24	21.05	24.27	26.75			
Uric acid	6.79	6.70	6.65	7.80	10.00	10.36	56.91	57.99
Ammonia	.68	.65	.67	.79	.87	1.22	2.80	2.91
Pure ash	4.09	7.35	4.74	3.89	3.74	4.82	9.56	8.54
Total SiO ₂	20.57	11.24	28.48	17.38	3.98	4.01	.92	.88

TABLE V.—Composition of the excrement (H_2O and silica-free).

	Corn. Chicken A ¹ .	Corn. Chicken B ¹ .	Corn. Chicken C ¹ .	Corn. Chicken D.	Corn. Chicken G.	Wheat. Chicken A ⁴ .	Oats. Chicken A ² .	Oats. Chicken A ² .
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Total nitrogen	6.64	7.60	8.45	5.65	7.19	6.93	4.28	4.20
Uric acid nitrogen ..	3.80	5.09	5.24	3.31	3.89	4.23	2.24	2.43
Ammonia nitrogen ..	1.04	1.17	1.25	1.12	1.44	.74	.66	.65
Crude proteid	11.25	8.33	12.28	7.59	11.64	12.32	9.61	7.07
Ether extract	5.19	4.39	4.55	4.29	6.86	4.05	2.20	2.15
Crude fiber	12.10	10.40	9.80	12.39	14.79	12.72	23.68	24.95
Ash	8.02	7.62	3.86	15.48	8.15	18.04	5.58	9.55
N.-free extract	50.76	52.64	52.25	48.93	45.11	39.27	52.45	48.20
Pentosans	22.20		29.12	24.98			25.68	29.58
Uric acid	11.41	15.28	15.73	9.95	11.68	12.70	6.72	7.29
Ammonia	1.26	1.42	1.52	1.36	1.75	.90	.80	.79

	Oats. Chicken B ² .	Oats. Chicken C ² .	Oats. Chicken C ² .	Oats. Chicken E.	Oats. Chicken F.	Oats. Chicken H.	Meat. Chicken M.	Meat. Chicken N.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Total nitrogen	5.23	4.58	5.11	5.52	6.09	6.86	27.20	27.35
Uric acid nitrogen ..	3.03	2.63	3.24	3.30	3.66	3.86	19.78	20.05
Ammonia nitrogen ..	.75	.63	.80	.82	.78	1.13	2.41	2.49
"Residual" nonpro- teid nitrogen							2.14	2.19
Crude proteid	9.12	8.25	6.67	8.71	10.23	11.68	17.91	16.39
Ether extract	2.83	2.51	1.94	2.06	2.30	1.95	1.42	1.45
Crude fiber	27.20	21.51	26.65	26.02	25.69	24.10		
Ash	5.48	8.66	6.94	4.94	4.11	5.40	9.97	8.85
N.-free extract	45.36	50.41	47.06	47.38	45.71	43.89		
Pentosans	32.29	29.75	30.83	30.81	29.39			
Uric acid	9.09	7.89	9.74	9.90	10.99	11.60	59.34	60.15
Ammonia	.91	.76	.97	.99	.95	1.37	2.92	3.02

TABLE VI.—Digestion experiments with corn.^a

CHICKEN A ¹ .—CORN.					CHICKEN B ¹ .—CORN.				
	Income.	Outgo.	Assimil- ation.	Coeffi- cient.		Income.	Outgo.	Assimil- ation.	Coeffi- cient.
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>			<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	
Organic matter ..	1,130.30	144.30	986.00	87.23	Organic matter ..	382.05	52.18	329.92	86.34
Crude proteid ...	126.80	20.46	106.34	83.36	Crude proteid ...	42.87	5.73	37.14	86.63
Ether extract ...	66.64	9.45	57.19	85.82	Ether extract ...	22.53	3.02	19.51	86.59
Crude fiber	26.53	22.02	4.51	17.00	Crude fiber	8.96	7.15	1.81	20.19
Nitrogen-free ex- tract	910.30	92.34	817.96	89.85	Nitrogen-free extract	307.70	36.21	271.49	88.23
Pentosans	69.23	40.39	28.84	41.66	Pentosans				

Duration of experiment.....days..	13	Duration of experiment.....days..	6
Sand consumed.....grams..	8.6	Water consumed.....grams..	599
Water consumed.....do....	985	Gain in weight.....ounces..	0.75
Gain in weight.....ounces..	7.5	Ratio H_2O to dry matter.....	1 to 0.647
Ratio H_2O to dry matter.....	1 to 1.164	NOTE.—Sand and marble consumed ad libitum, but amounts not observed.	
Ratio sand to dry matter.....	1 to 133.9		

^a See chart at back of bulletin for graphic record of digestion coefficients.

TABLE VI.—*Digestion experiments with corn*—Continued.

CHICKEN C ¹ .—CORN.					CHICKEN D.—CORN.				
	Income.	Outgo.	Assimilation.	Coefficient.		Income.	Outgo.	Assimilation.	Coefficient.
	Grams.	Grams.	Grams.			Grams.	Grams.	Grams.	
Organic matter...	429.61	61.14	368.47	85.77	Organic matter	679.03	89.00	590.03	86.89
Crude proteid...	48.20	9.51	38.69	80.27	Crude proteid...	73.21	9.23	63.98	87.39
Ether extract...	25.33	3.52	21.81	86.01	Ether extract...	40.64	5.21	35.43	87.18
Crude fiber.....	10.08	7.59	2.49	24.70	Crude fiber.....	16.75	15.07	1.68	10.08
Nitrogen-free extract.....	346.00	40.50	305.50	88.29	Nitrogen-free extract.....	548.40	59.48	488.92	89.15
Pentosans.....	26.31	22.57	3.74	14.21	Pentosans.....	46.22	30.37	15.85	34.29
Duration of experiment.....days.. 6					Duration of experiment.....days.. 8				
Water consumed.....grams.. 398					Sand consumed.....grams.. 28.09				
Loss in weight.....ounces.. 0.25					Water consumed.....do.... 720				
Ratio H ₂ O to dry matter..... 1 to 1.10					Gain in weight.....ounces.. 4				
NOTE.—Sand and marble consumed ad libitum, but amounts undetermined.					Ratio H ₂ O to dry matter..... 1 to 0.956				
					Ratio sand to dry matter..... 1 to 24.52				
CHICKEN G.—CORN.					AVERAGE COEFFICIENTS, ALL CORN EXPERIMENTS.				
	Income.	Outgo.	Assimilation.	Coefficient.					
	Grams.	Grams.	Grams.						
Organic matter..	391.84	50.87	340.97	87.02	Organic matter.....	86.65			
Crude proteid...	42.24	7.55	34.69	82.12	Crude proteid.....	83.95			
Ether extract...	23.44	4.44	19.00	81.05	Ether extract.....	85.32			
Crude fiber...	9.66	9.59	0.07	0.72	Crude fiber.....	a [14.53]			
Nitrogen-free extract.....	316.50	29.26	287.24	90.75	Nitrogen-free extract.....	89.25			
Pentosans.....									
Duration of experiment.....days.. 9									
Water consumed.....grams.. 568									
Loss in weight.....ounces.. 1									
Ratio H ₂ O to dry matter..... 1 to 0.788									
NOTE.—No sand was consumed.									

^a See page 59.

TABLE VII.—*Digestion experiments with oats,^a wheat, and meat.*

CHICKEN A ² .—OATS.					CHICKEN A ³ .—OATS.				
	Income.	Outgo.	Assimilation.	Coefficient.		Income.	Outgo.	Assimilation.	Coefficient.
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>			<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	
Organic matter...	561.45	211.60	349.85	62.31	Organic matter...	373.48	133.40	240.08	64.28
Crude proteid...	76.22	20.94	55.28	72.52	Crude proteid...	50.69	11.46	39.23	77.39
Ether extract...	29.72	5.36	24.36	81.96	Ether extract...	19.76	3.49	16.27	82.34
Crude fiber.....	64.94	57.67	7.27	11.19	Crude fiber.....	43.19	40.39	2.80	6.48
Nitrogen-free extract.....	390.60	127.60	263.00	67.33	Nitrogen-free extract.....	259.70	78.03	181.67	69.95
Pentosans.....	85.35	62.54	22.81	26.72	Pentosans.....	56.76	47.89	8.87	15.63
Duration of experiment.....days.. 11					Duration of experiment.....days.. 8				
Sand consumed.....grams.. 31.92					Sand consumed.....grams.. 52.1				
Water consumed.....do.... 1,056					Water consumed.....do.... 757				
Gain or loss in weight..... None.					Loss in weight.....ounces.. 1.75				
Ratio H ₂ O to dry matter..... 1 to 0.55					Ratio H ₂ O to dry matter..... 1 to 0.510				
Ratio sand to dry matter..... 1 to 18.74					Ratio sand to dry matter..... 1 to 0.742				
CHICKEN B ² .—OATS.					CHICKEN C ² .—OATS.				
	Income.	Outgo.	Assimilation.	Coefficient.		Income.	Outgo.	Assimilation.	Coefficient.
	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>			<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	
Organic matter...	480.89	155.80	325.09	67.60	Organic matter...	298.97	118.75	180.22	60.28
Crude proteid...	65.29	16.82	48.47	74.24	Crude proteid...	40.59	11.85	28.74	70.80
Ether extract....	25.45	5.23	20.22	79.45	Ether extract....	15.83	3.61	12.22	77.19
Crude fiber.....	55.62	50.17	5.45	9.80	Crude fiber.....	34.58	30.90	3.68	10.64
Nitrogen-free extract.....	334.50	83.62	250.88	74.99	Nitrogen-free extract.....	208.00	72.41	135.59	65.19
Pentosans.....	73.10	59.56	13.54	18.52	Pentosans.....	45.45	42.73	2.72	5.98
Duration of experiment.....days.. 9					Duration of experiment.....days.. 8				
Sand consumed.....grams.. 31.5					Water consumed.....grams.. 563				
Water consumed.....do.... 828					Loss in weight.....ounces.. 2				
Gain in weight.....ounces.. 0.25					Ratio H ₂ O to dry matter..... 1 to 0.549				
Ratio H ₂ O to dry matter..... 1 to 0.601					NOTE.—Sand offered ad libitum, but amount consumed was undetermined. •				
Ratio sand to dry matter..... 1 to 15.81									

^a See chart at back of bulletin for graphic record of digestion coefficients.

TABLE VII.—*Digestion experiments with oats, wheat, and meat*—Continued.

CHICKEN C ² .—OATS.					CHICKEN E.—OATS.				
	Income.	Outgo.	Assimilation.	Coefficient.		Income.	Outgo.	Assimilation.	Coefficient.
	Grams.	Grams.	Grams.			Grams.	Grams.	Grams.	
Organic matter...	271.82	88.43	182.89	67.41	Organic matter...	349.88	125.30	224.58	64.18
Crude proteid...	36.84	7.17	29.67	80.53	Crude proteid...	47.49	12.99	34.50	72.65
Ether extract....	14.86	2.09	12.27	85.44	Ether extract....	18.52	3.08	15.44	83.36
Crude fiber.....	31.39	28.63	2.76	8.79	Crude fiber.....	40.47	38.75	1.72	4.25
Nitrogen-free extract.....	188.70	50.54	138.16	73.21	Nitrogen-free extract.....	243.40	70.61	172.89	71.03
Pentosans.....	41.24	33.11	8.13	19.71	Pentosans.....	53.18	45.87	7.31	13.74
Duration of experiment.....days..				7	Duration of experiment.....days..				8
Sand consumed.....grams..				64.88	Sand consumed.....grams..				27.44
Water consumed.....do....				446	Water consumed.....do....				615
Loss in weight.....ounces..				2.50	Loss in weight.....ounces..				2
Ratio H ₂ O to dry matter.....			1 to 0.629		Ratio H ₂ O to dry matter.....			1 to 0.588	
Ratio sand to dry matter.....			1 to 4.39		Ratio sand to dry matter.....			1 to 13.19	
CHICKEN F.—OATS.					CHICKEN H.—OATS.				
	Income.	Outgo.	Assimilation.	Coefficient.		Income.	Outgo.	Assimilation.	Coefficient.
	Grams.	Grams.	Grams.			Grams.	Grams.	Grams.	
Organic matter...	194.59	69.86	124.73	64.10	Organic matter...	301.08	103.50	197.58	65.62
Crude proteid...	26.42	8.51	17.91	67.75	Crude proteid...	51.36	14.81	36.55	71.16
Ether extract....	10.30	1.92	8.38	81.35	Ether extract....	12.79	2.47	10.32	80.68
Crude fiber.....	22.51	21.38	1.13	5.02	Crude fiber.....	33.61	30.66	3.05	9.07
Nitrogen-free extract.....	135.40	38.04	97.36	71.90	Nitrogen-free extract.....	208.30	55.65	147.65	72.62
Pentosans.....	29.58	24.46	5.12	17.31	Pentosans.....				
Duration of experiment.....days..				8	Duration of experiment.....days..				9
Sand consumed.....				None.	Sand consumed.....				None.
Water consumed.....grams..				339	Water consumed.....grams..				462
Loss in weight.....ounces..				2.25	Loss in weight.....ounces..				2.50
Ratio H ₂ O to dry matter.....			1 to 0.594		Ratio H ₂ O to dry matter.....			1 to 0.678	
CHICKENS A ² AND A ³ .—OATS. COMBINED COEFFICIENT.					CHICKENS A, B, C, E, F, AND H.—OATS. COMBINED COEFFICIENT.				
Organic matter.....				63.29	Organic matter.....				64.77
Crude proteid.....				74.95	Crude proteid.....				73.38
Ether extract.....				82.15	Ether extract.....				81.48
Crude fiber.....				8.83	Crude fiber.....				8.15
Nitrogen-free extract.....				68.69	Nitrogen-free extract.....				70.77
Pentosans.....				21.17					
CHICKENS C ² AND C ³ .—OATS. COMBINED COEFFICIENT.									
Organic matter.....				63.84					
Crude proteid.....				75.66					
Ether extract.....				81.81					
Crude fiber.....				9.71					
Nitrogen-free extract.....				69.20					
Pentosans.....				12.84					

TABLE VII.—*Digestion experiments with oats, wheat, and meat*—Continued.

CHICKEN A ⁴ .—WHEAT.					CHICKEN M.—MEAT DIET.				
	Income.	Outgo.	Assimi- lation.	Coeffi- cient.		Income.	Outgo.	Assimi- lation.	Coeffi- cient.
	Grams.	Grams.	Grams.			Grams.	Grams.	Grams.	
Organic matter..	416.17	66.81	349.36	83.94	Organic matter..	96.97	12.35	84.62	87.26
Crude proteid...	53.24	12.03	41.21	77.40	Crude proteid...	85.54	8.63	76.91	89.91
Ether extract...	9.62	3.96	5.66	58.83	Ether extract...	5.09	.68	4.41	86.59
Crude fiber.....	7.46	12.43	—4.97	.....	Crude fiber.....				
Nitrogen-free ex- tract.....	345.80	38.38	307.42	88.90	Nitrogen-free extract.....				
Duration of experiment.....days..				8	Duration of experiment.....days..				6
Sand consumed.....grams..				52.1	Sand consumed.....				None.
Water consumed.....do... ..				722	Water consumed.....grams..				253
Loss in weight.....ounces..				1	Gain in weight.....ounce..				0.5
Ratio H ₂ O to dry matter.....				1 to 0.588	Ratio H ₂ O to dry matter.....				1 to 0.396
Ratio sand to dry matter.....				1 to 8.15					
CHICKEN N.—MEAT DIET.					CHICKENS M AND N.—AVERAGE COEFFI- CIENTS.				
	Income.	Outgo.	Assimi- lation.	Coeffi- cient.					
	Grams.	Grams.	Grams.						
Organic matter..	96.97	12.76	84.21	86.84	Organic matter.....				87.05
Crude proteid...	85.54	8.11	77.43	90.51	Crude proteid.....				90.20
Ether extract...	5.09	.71	4.38	86.01	Ether extract.....				86.30
Crude fiber.....									
Nitrogen-free ex- tract.....									
Duration of experiment.....days..				6					
Sand consumed.....				None.					
Water consumed.....grams..				265					
Loss in weight.....ounces..				1.5					
Ratio H ₂ O to dry matter.....				1 to 0.378					

TABLE VIII.—*Metabolic nitrogen of excrement.*

Subject.	Total nitrogen.	Extracted 95 per cent alcohol.	Extracted absolute alcohol.	Extracted ether extract.	Extracted acetic ether.	95 per cent alcohol, per cent of total nitrogen.	Absolute alcohol, per cent of total nitrogen.	Ether extract, per cent of total nitrogen.	Acetic ether, per cent of total nitrogen.	95 per cent alcohol, per cent of fecal nitrogen.	Ether extract, per cent of fecal nitrogen.	Acetic ether, per cent of fecal nitrogen.	Absolute alcohol, per cent of fecal nitrogen.
	<i>Perct.</i>	<i>Perct.</i>	<i>Perct.</i>	<i>Perct.</i>	<i>Perct.</i>	<i>Perct.</i>	<i>Perct.</i>	<i>Perct.</i>	<i>Perct.</i>	<i>Perct.</i>	<i>Perct.</i>	<i>Perct.</i>	<i>Perct.</i>
Chicken A ¹ ...	6.12	0.81	.....	0.098	.....	13.23	.....	1.60	.....	.....	.....	.....	.....
Chicken B ¹ ...	6.72	.83	.....	.12	.....	12.85	.....	1.78	.....	70.33	10.17	.....	.....
Chicken C ¹ ...	7.62	1.06	.....	.....	.....	13.91	.....	.....	.....	59.88	.....	.....	.....
Chicken D....	4.74	.60	.....	.10	0.10	12.65	.....	2.10	2.11	.....	.....	9.80	.....
Chicken A ² ...	6.12	.51	.....	.12	.....	14.91	.....	1.96	.....	.....	9.80	.....	.....
Chicken A ² ...	3.42	.51	.....	.....	.....	14.91	.....	.....	.....	46.36	.....	.....	.....
Chicken A ² ...	3.12	.43	.....	.10	.21	13.78	.....	3.20	6.73	.....	.....	25	.....
Chicken B ² ...	3.91	.50	.....	.12	.19	12.78	.....	3.07	4.85	.....	11.90	17.43	.....
Chicken C ² ...	3.89	.38	.....	.....	.....	9.77	.....	.....	.....	.....	11	.....	.....
Chicken C ² ...	3.49	.60	.....	.....	.....	17.19	.....	.....	.....	.....	.....	.....	.....
Chicken E....	4.35	.36	0.85	.....	.....	8.98	8.04	.....	.....	.....	31.81	.....	31.81
Chicken F....	5.54	.....	.29	.....	.....	.....	5.14	.....	.....	.....	19.46	.....	19.46
Chicken M....	26.09	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Chicken N....	26.37	.....	.93	.07	.....	.....	3.54	.....	.....	.....	2.65	.....	35.22

TABLE IX.—*Digestion coefficients of poultry and other farm animals compared.*

	Organic matter.	Crude proteid.	Ether extract.	Crude fiber.	Nitrogen-free extract.
CORN, ETC.					
Poultry: Average of 5 experiments with corn (Brown).....	86.65	83.95	85.32	a [14.53]	89.25
Poultry: Average of 4 experiments with corn (Paraschtschuk) ^a	89.21	92.50	83.43	31.20	91.76
Poultry: Average of 3 experiments with corn (Fields & Ford) ^a	86.4	49.8	91.7	.....	92.5
Poultry: Average of 3 experiments with corn meal (Fields & Ford).....	85.5	48.4	98.1	.....	91.5
Poultry: Average of 3 experiments with Kafir corn (Fields & Ford).....	87.7	52.9	73.7	20.1	96.8
Poultry: Average of 3 experiments with Kafir corn meal (Fields & Ford).....	87.2	42.6	82.7	35.5	82.7
Ruminants: Average of 12 experiments with corn (Wolff) ^a	91	72	85	77	94
Horses: Average of 2 experiments with corn (Wolff).....	89	77	61	70	94
Swine: Average of 4 experiments with corn (Wolff).....	92	86	76	40	95
OATS.					
Poultry: Average of 8 experiments (Brown).....	64.77	73.38	81.48	a [8.15]	70.77
Poultry: 1 experiment (Grost) ^a.....	.....	62.34	84.01	.50	60.82
Ruminants: Average of 39 experiments (Wolff) ^a ..	70	78	83	20	76
Horses: Average of 8 experiments (Wolff).....	68	86	71	21	74

a See page 59.

TABLE IX.—*Digestion coefficients of poultry and other farm animals compared—Cont'd.*

	Organic matter.	Crude protein.	Ether extract.	Crude fiber.	Nitrogen- free ex- tract.
WHEAT.					
Poultry: 1 experiment (Brown)	83.94	77.40	58.88	.....	86.02
Poultry: Average of 2 experiments (Kalugin) ⁵⁰ ...	81.92	56.91	55.21	29.95	93.30
Poultry: 1 experiment (Lehmann) ⁵²	81.86	77.12	39.67	None.	86.50
Swine: 1 experiment (Snyder) ⁵³ .....	.....	70	60	80	74
PEAS.					
Poultry: Average of 2 experiments with peas (Kalugin) ⁵⁰	75.52	90.32	83.71	13.75	91.65
Poultry: 1 experiment with peas (Lehmann) ⁵² ..	78.62	83.68	76.81	.....	77.96
Ruminants: Average of 2 experiments with peas (Wolff) ⁵¹	90	89	75	66	93
Horses: 1 experiment with peas (Wolff)	80	88	9	8	89
Swine: Average of 10 experiments with peas (Wolff)	91	88	49	71	96
Poultry: Average of 3 experiments with cowpeas (Fields & Ford) ⁵⁴	71.5	40.5	88.7	18.4	87.1
Poultry: Average of 3 experiments with cowpea meal (Fields & Ford)	72.2	43.7	88.7	9.6	87.8
BARLEY.					
Poultry: Average of 2 experiments (Kalugin) ⁵⁰ ...	77.17	79.22	68.29	.....	89.07
Poultry: 1 experiment (Grost) ⁵¹ .....	.....	75.41	67.43	.20	81.11
Ruminants: Average of 4 experiments (Wolff) ⁵¹ ..	86	70	89	50	92
Horses: 1 experiment (Wolff)	87	80	42	100	87
Swine: Average of 8 experiments (Wolff)	82	76	65	15	90
RYE.					
Poultry: 1 experiment (Grost) ⁵¹ .....	.....	70.72	16.59	2.40	87.80
BUCKWHEAT.					
Poultry: Average of 2 experiments (Kalugin) ⁵⁰ ...	69.38	59.40	89.22	2.02	86.99
MILLET.					
Poultry: Average of 2 experiments (Kalugin) ⁵⁰...	.....	62.40	85.71	5.55	98.39
BEEF.					
Poultry: Average of 2 experiments (Brown)	87.05	90.20	86.30	.....	.....

TABLE X.—Feeding standards for poultry based on digestion coefficients.

I.—AMOUNT OF NUTRIENTS DAILY CONSUMED BY 100 POUNDS LIVE WEIGHT.

	Organic matter.	Crude proteid.	Ether extract.	Nitrogen-free extract.	Nutritive ratio.	Fuel value.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>		<i>Calories.</i>
Hens (3 to 4 pounds), corn	4.83	0.53	0.28	3.89	1:8.6	100,732
Hens (3 to 4 pounds), oats	2.84	.37	.15	1.97	1:6.8	54,065
Hens (3 to 4 pounds), wheat	3.27	.42	.07	2.72	1:6.9	66,259

II.—AMOUNT OF NUTRIENTS DAILY ASSIMILATED BY 100 POUNDS LIVE WEIGHT.

Hens (3 to 4 pounds), corn	4.19	0.45	0.24	3.46	1: 9.0	88,623
Hens (3 to 4 pounds), oats	1.83	.28	.12	1.39	1: 6.0	39,438
Hens (3 to 4 pounds), wheat	2.70	.32	.04	2.42	1: 7.8	56,681
Oxen (at rest) ^a		.07	.01	.80	1:11.8	
Cows (milk yield, 11 pounds) ^a		.16	.08	1.00	1: 6.7	
Sheep (coarse wool) ^a		.12	.02	1.05	1: 9.1	
Horses (light work) ^a		.15	.04	.95	1: 7.0	
Cows (milk yield, 27½ pounds) ^a		.33	.08	1.30	1: 4.5	
Oxen (severe work) ^a		.28	.08	1.30	1: 5.3	
Horses (severe work) ^a		.25	.08	1.33	1: 6.0	
Swine (fattening, third period) ^a		.27	.04	1.80	1: 7.0	

III.—DIGESTIBLE NUTRIENTS PER DAY PER 100 POUNDS LIVE WEIGHT.^a

Capons (9 to 12 pounds)	2.30	0.30	0.20	1.74	1:7.5	46,000
Hens (3 to 5 pounds)	3.90	.50	.30	2.95	1:7.4	76,000
Hens (5 to 7 pounds)	2.70	.40	.20	2.00	1:6.2	53,000

IV.—AMOUNT OF ASSIMILATED NUTRIENTS IN 100 POUNDS OF THE GRAIN FED.

Corn	85.35	9.27	4.93	70.82	1:8.9	
Oats	62.58	9.62	4.16	47.56	1:6.0	
Wheat	82.23	9.63	1.83	70.08	1:7.5	

V.—COST OF 1 POUND OF THE ASSIMILATED NUTRIENTS OF THE GRAIN.^b

	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>		
Corn	1.41	1.44	1.46	1.39		
Oats	2.82	2.17	1.98	2.25		
Wheat	1.78	1.96	2.55	1.76		

^a Feeding standard compiled by Wheeler.⁶⁶

^b With corn at 60 cents, oats at 40 cents, and wheat at 80 cents per bushel.

TABLE XI.—*Cost of the principal nutrients.*^a

	Experiments with corn.								
	Chicken A ¹ .			Chicken B ¹ .			Chicken C ¹ .		
	In- come.	Outgo.	Assimil- ation.	In- come.	Outgo.	Assimil- ation.	In- come.	Outgo.	Assimil- ation.
	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>
Organic matter.....	3.0406	0.3881	2.6524	1.0277	0.1402	0.8875	1.1556	0.1645	0.9911
Crude proteid	.0380	.0061	.0319	.0128	.0017	.0111	.0144	.0028	.0116
Ether extract.....	.0106	.0015	.0091	.0036	.0005	.0031	.0040	.0006	.0034
Nitrogen-free extract....	1.9844	.2013	1.7831	.6707	.0789	.5918	.7542	.0883	.6659
Value of gain (+) or loss (−) in weight.....	+7.5			+.75			−.25		

	Experiments with corn.						Experiments with oats.		
	Chicken D ¹ .			Chicken G.			Chicken A ² .		
	In- come.	Outgo.	Assimil- ation.	In- come.	Outgo.	Assimil- ation.	In- come.	Outgo.	Assimil- ation.
	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>
Organic matter.....	1.8145	0.2385	1.5760	1.0501	0.1363	0.9138	1.7405	0.6559	1.0846
Crude proteid	.0212	.0027	.0185	.0122	.0021	.0101	.0351	.0096	.0255
Ether extract.....	.0065	.0008	.0057	.0034	.0007	.0027	.0053	.0009	.0044
Nitrogen-free extract....	1.1955	.1297	1.0658	.6899	.0647	.6252	.9218	.3011	.6207
Value of gain (+) or loss (−) in weight.....	+4			+1			None.		

	Experiments with oats.								
	Chicken A ³ .			Chicken B ³ .			Chicken C ³ .		
	In- come.	Outgo.	Assimil- ation.	In- come.	Outgo.	Assimil- ation.	In- come.	Outgo.	Assimil- ation.
	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>
Organic matter.....	1.1577	0.4135	0.7442	1.4907	0.4829	1.0078	0.9268	0.3681	0.5587
Crude proteid	.0233	.0053	.0180	.0300	.0077	.0223	.0186	.0054	.0132
Ether extract.....	.0035	.0006	.0029	.0045	.0009	.0036	.0028	.0006	.0022
Nitrogen-free extract....	.6129	.1841	.4287	.7894	.1974	.5920	.4908	.1708	.3200
Value of gain (+) or loss (−) in weight.....	−1.75			+.25			−2		

	Experiments with oats.								
	Chicken C ⁴ .			Chicken E.			Chicken F.		
	In- come.	Outgo.	Assimil- ation.	In- come.	Outgo.	Assimil- ation.	In- come.	Outgo.	Assimil- ation.
	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>
Organic matter.....	0.8410	0.2741	0.5669	1.0846	0.3884	0.6962	0.6082	0.2165	0.3867
Crude proteid.....	.0169	.0023	.0136	.0275	.0075	.0200	.0121	.0039	.0082
Ether extract.....	.0026	.0004	.0022	.0033	.0005	.0028	.0018	.0003	.0015
Nitrogen-free extract....	.4453	.1193	.3260	.5744	.1664	.4080	.3195	.0897	.2298
Value of gain (+) or loss (−) in weight.....	−2.5			−2			−2.25		

^a With corn at 60 cents, oats at 40 cents, and wheat at 80 cents per bushel.

TABLE XI.—*Cost of the principal nutrients—Continued.*

	Experiments with oats.			Experiments with wheat.		
	Chicken H.			Chicken A ⁴ .		
	Income.	Outgo.	Assimila- tion.	Income.	Outgo.	Assimila- tion.
	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>
Organic matter	0.9482	0.8260	0.6222	1.3733	0.2204	1.1529
Crude proteid	.0297	.0066	.0211	.0223	.0060	.0173
Ether extract	.0018	.0003	.0015	.0007	.0003	.0004
Nitrogen-free extract	.4655	.1274	.3381	.9440	.1047	.8393
Value of gain (+) or loss (−) in weight	−2.5			−1		

TABLE XII.—*Daily body weight in feeding experiments with corn, oats, wheat, and beef.*

	Experiments with corn.								
	(1) Chick- en A ¹ .	(2) Chick- en B ¹ .	(3) Chick- en C ¹ .	(4) Chick- en D.	(5) Chick- en G.	(6) Chick- en I ¹ .	(7) Chick- en I ² .	(8) Chick- en 2 ¹ .	(9) Chick- en 2 ² .
	<i>Lbs. oz.</i>	<i>Lbs. oz.</i>	<i>Lbs. oz.</i>	<i>Lbs. oz.</i>	<i>Lbs. oz.</i>	<i>Lbs. oz.</i>	<i>Lbs. oz.</i>	<i>Lbs. oz.</i>	<i>Lbs. oz.</i>
First day	3 6	3 1	3 15	4 2½	2 13½	2 9½	2 8½	2 11	2 11½
Second day	3 8	3 1	3 14½	4 2½	2 13	2 10	2 8½	2 13	2 13
Third day	3 8½	3 ½	3 14½	4 3	2 13	2 10	2 9	2 12	2 12½
Fourth day	3 9	3 ½	3 14	4 3	2 13	2 10	2 9	2 12	2 12½
Fifth day	3 9½	3 1	3 14½	4 5	2 13	2 10	2 9	2 12	2 12
Sixth day	3 9½	3 1½	3 14½	4 5	2 12½	2 11	2 9½		
Seventh day	3 10			4 6	2 12½	2 10½	2 9		
Eighth day	3 12½			4 6	2 12½	2 10½	2 8½		
Ninth day	3 12½				2 12½				
Tenth day	3 12½								
Eleventh day	3 13								
Twelfth day	3 13½								
Thirteenth day	3 13½								

	Experiments with corn.				Experiments with oats.				
	(10) Chick- en 3 ¹ .	(11) Chick- en 3 ² .	(12) Chick- en 4 ¹ .	(13) Chick- en 4 ² .	(14) Chick- en A ² .	(15) Chick- en A ² .	(16) Chick- en B ² .	(17) Chick- en C ² .	(18) Chick- en C ³ .
	<i>Lbs. oz.</i>	<i>Lbs. oz.</i>	<i>Lbs. oz.</i>	<i>Lbs. oz.</i>	<i>Lbs. oz.</i>	<i>Lbs. oz.</i>	<i>Lbs. oz.</i>	<i>Lbs. oz.</i>	<i>Lbs. oz.</i>
First day	2 5	2 0	2 7½	2 ½	3 9½	3 9½	3 3	3 10	3 8
Second day	2 5½	2 1	2 7½	2 1	3 10	3 9	3 2½	3 10½	3 5
Third day	2 5	2 0	2 7½	2 1	3 11	3 8½	3 2½	3 9	3 5
Fourth day	2 6	2 0	2 9½	2 0	3 1½	3 8½	3 2½	3 9	3 5
Fifth day	2 7	2 0	2 10	1 15½	3 10	3 8½	3 3	3 8½	3 5
Sixth day	2 7	2 0	2 9	1 15	3 10½	3 8	3 2½	3 9	3 5
Seventh day	2 7	2 0	2 9½	2 0	3 11	3 8	3 3	3 8½	3 5½
Eighth day	2 7	2 0	2 9½	2 0	3 9½	3 7½	3 3½	3 8	
Ninth day	2 7	2 ½	2 9½	1 15½	3 11		3 3½		
Tenth day	2 7	2 ½	2 9½	2 1	3 9½				
Eleventh day			2 9½	2 1	3 9½				
Twelfth day			2 9	2 ½	3 9½				
Thirteenth day			2 9	2 0	3 9½				
Fourteenth day			2 9	2 0					

TABLE XII.—*Daily body weight in feeding experiments with corn, etc.—Continued.*

	Experiments with oats.					Experiments with wheat.		Experiments with beef.	
	(19) Chick- en E.	(20) Chick- en F.	(21) Chick- en H.	(22) Chick- en I ^a .	(23) Chick- en I ^a .	(24) Chick- en A ⁴ .	(25) Chick- en A ⁴ .	(26) Chick- en M.	(27) Chick- en N.
	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.	Lbs. oz.
First day	3 7	2 3½	3 3½	2 0	2 4½	3 9½	2 10	3 5	3 7
Second day	3 7½	2 3½	3 2	2 2½	2 3½	3 9½	2 10	3 4½	3 7
Third day	3 6½	2 3½	3 3	2 2	2 3½	3 9	2 10	3 4	3 6½
Fourth day	3 6	2 2½	3 2½	2 2½	2 3	3 9	2 10	3 3	3 6
Fifth day	3 6½	2 2½	3 2	2 2½	2 3	3 8½	2 10	3 5½	3 5½
Sixth day	3 5½	2 1½	3 2	2 2½	3 2	3 9½	2 9	3 5½	3 5½
Seventh day	3 5	2 1	3 1	2 2		3 9	2 9		
Eighth day	3 5	2	3 1			3 8½	2 8½		
Ninth day			3 ½				2 8½		
Tenth day							2 8		
Eleventh day							2 8		
Twelfth day							2 8		
Thirteenth day							2 7½		
Fourteenth day							2 7		
Fifteenth day							2 5		

NOTE.—Experiments Nos. 1 to 5, 14 to 21, 24, 26, and 27 are by Brown; Nos. 6 to 13, 22, 23, and 25 by Clark.

TABLE XIII.—*The consumption and excretion of SiO₂.*

	Total SiO ₂ ingested.	Total SiO ₂ excreted.	Per cent SiO ₂ of total excre- ment.
	Grams.	Grams.	
Chicken A ¹ .—Corn	8.60	7.41	3.76
Chicken B ¹ .—Corn	(a)	6.07	7.81
Chicken C ¹ .—Corn	(a)	4.49	5.22
Chicken D.—Corn	28.09	14.60	10.08
Chicken A ² .—Oats	31.92	45.27	14.85
Chicken A ³ .—Oats	52.10	48.24	22.11
Chicken B ² .—Oats	31.50	45.80	20.57
Chicken C ² .—Oats	(a)	19.03	11.24
Chicken C ³ .—Oats	64.38	44.80	28.48
Chicken E.—Oats	27.44	32.75	17.38
Chicken F.—Oats	None.	3.64	3.98
Chicken H.—Oats	None.	5.69	4.01
Chicken G.—Corn	None.	.40	.57
Chicken A ⁴ .—Wheat	52.11	8.36	7.55

a Unobserved.

TABLE XIV.—*Excretion of SiO₂ when no sand was ingested.*

Date.	Chicken G, corn. (No sand after May 23.)		Chicken H, oats. (No sand after May 23.)		Chicken I, corn. (No sand after May 23.)	
	Total SiO ₂ in excre- ment.	Per cent SiO ₂ of to- tal excre- ment.	Total SiO ₂ in excre- ment.	Per cent SiO ₂ of to- tal excre- ment.	Total SiO ₂ in excre- ment.	Per cent SiO ₂ of to- tal excre- ment.
	<i>Grams.</i>		<i>Grams.</i>		<i>Grams.</i>	
June 1.....	0.1868	5.66	0.9633	4.94	0.3477	3.78
June 6.....					.0600	.54
June 14.....					.0951	.41
June 17.....					.0520	.38
June 19.....					.0470	.33
June 21.....	.6462	3.87	.4760	4.25	.0510	.49
July 17.....	.1064	1.33	.3894	3.81	.0520	.38

Date.	Chicken F, oats. (No sand after Feb. 26.)		Chicken M, meat. (No sand after March 27.)	Chicken N, meat. (No sand after March 27.)
	Total SiO ₂ in excre- ment.	Per cent SiO ₂ of to- tal excre- ment.	Total SiO ₂ for six days in excre- ment.	Total SiO ₂ for six days in excre- ment.
	<i>Grams.</i>		<i>Grams.</i>	<i>Grams.</i>
March 2.....	0.7172	6.52		
March 3.....	.6450	5.45		
March 12.....	.3300	3.11		
April 15-20.....			0.4623	
April 15-20.....				0.4514

BIBLIOGRAPHY.

- (1) SALKOWSKI, E. Ueber das Verhalten der Pentosen im Tierkörper. *Centralbl. f. med. Wissensch.*, Berlin, 31. J., No. 11, 18. März, pp. 193-194. 1893.
- (2) CREMER, MAX. Ueber das Verhalten einiger Zuckerarten im thierischen Organismus. *Ztschr. f. Biol.*, München & Leipzig, Bd. 29, n. F., Bd. 11, pp. 484-553. 1892.
- (3) EBSTEIN, WILHELM. Einige Bemerkungen über das Verhalten der Pentaglycosen (Pentosen) im menschlichen Organismus. *Arch. f. path. Anat. [etc.] [Virchow]*, Berlin, Bd. 129, 12. F., Bd. 9, Heft 3, 7. Sept., pp. 401-412. 1892.
- (4) SLOVZOV, B. Du sort des pentosanes dans l'organisme animal. [Russian text.] *Bull. Acad. imp. d. sc. de St.-Petersbourg*, 5. s., v. 15, No. 4, Nov., pp. 423-434. 1901.
- (5) MEISSNER, G. Beiträge zur Kenntniss des Stoffwechsels im thierischen Organismus. *Ztschr. f. rat. Med.*, Leipzig & Heidelberg, 3. R., Bd. 31, Heft 1-2, p. 216. 1868.
- (6) ROBERTS, SIR WILLIAM. The Croonian lectures on the chemistry and therapeutics of uric acid gravel and gout. *Brit. Med. Journ.*, London (1642), v. 1, June 18, pp. 1285-1290. 1892.
- (7) VON SCHRÖDER, W. Ueber die Bildungsstätte der Harnsäure im Organismus. *Arch. f. Anat. u. Physiol.*, Leipzig, *Physiol. Abth.*, Suppl.-Bd., 23. Dec., pp. 113-146. 1880.
- (8) ZALESKY, NICOLAUS. Untersuchungen über den uraemischen Process und die Function der Nieren. iv, 70 pp., 4 pls. 8°. Tübingen. 1865.
- (9) MINKOWSKI, O. Ueber den Einfluss der Leberexstirpation auf den Stoffwechsel. *Arch. f. exper. Path. u. Pharm.*, Leipzig, Bd. 21, Heft 1, 24. Feb., pp. 41-87. 1886.
- (10) MINKOWSKI. Ueber die Ursachen der Milchsäureausscheidung nach der Leberexstirpation. *Arch. f. exper. Path. u. Pharm.*, Leipzig, Bd. 31, Heft 2-3, 11. Apr., pp. 214-221. 1893.
- (11) LANG, S. Ueber die Stickstoffausscheidung nach Leberexstirpation. *Ztschr. f. physiol. Chem.*, Strassburg, Bd. 32, Heft 3-4, 27. Apr., pp. 320-340. 1901.
- (12) KOWALEWSKI, KATHARINA; AND SALASKIN, S. Ueber die Bildung von Harnsäure in der Leber der Vögel. *Ztschr. f. physiol. Chem.*, Strassburg, Bd. 33, Heft 1-2, 7. Aug., pp. 210-222. 1901.
- (13) MENDEL, LAFAYETTE B.; AND JACKSON, HOLMES C. On the excretion of kynurenic acid. *Amer. Journ. Physiol.*, Boston, v. 2, No. 1, Nov. 22, pp. 1-28. 1898.
- (14) PATON, D. NOËL. Studies of the metabolism in the dog before and after removal of the spleen. *Journ. Physiol.*, London, (1899-1900), v. 25, No. 6, Nov. 12, pp. 443-461. 1900.
- (15) LO MONACO, D. Osservazioni sull' escrezione e sulla formazione dell' acido urico nell' organismo. *Schmidt's Jahrb.*, Leipzig, Bd. 252, No. 2, pp. 109-110. 1896.
- (16) VON MACH, W. Ueber die Umwandlung von Hypoxanthin in Harnsäure im Organismus der Vögel. *Arch. f. exper. Path. u. Pharm.*, Leipzig, Bd. 23, Heft 1-2, 12. Mai, pp. 148-149. 1887.
- (17) MINKOWSKI. Untersuchungen zur Physiologie und Pathologie der Harnsäure bei Säugethiere. *Arch. f. exper. Path. u. Pharm.*, Leipzig, Bd. 41, Heft 6, 20. Dec., pp. 375-420, pls. 1-2. 1898.

- (18) BURIAN, RICHARD; AND SCHUR, HEINRICH. Ueber die Stellung der Purinkörper im menschlichen Stoffwechsel. *Arch. f. d. ges. Physiol.*, Bonn, Bd. 80, Heft 6-7, 17. Mai, pp. 241-343. 1900.
- (19) KRÜGER, MARTIN; AND SCHMID, JULIUS. Die Entstehung der Harnsäure aus freien Purinbasen. *Ztschr. f. physiol. Chem.*, Strassburg, Bd. 34, Heft 5-6, 25. Feb., pp. 549-565. 1902.
- (20) MILROY, T. H. Acid poisoning in birds. *Journ. Physiol.*, London, (1901-1902), v. 27, *Proc. Physiol. Soc.*, pp. xii-xiv. 1901.
- (21) WIENER, HUGO. Ueber Zersetzung und Bildung der Harnsäure im Thierkörper. *Arch. f. exper. Path. u. Pharm.*, Leipzig, Bd. 42, Heft 5-6, 29. Juni, pp. 375-398. 1899.
- (22) SCHULTZEN, O.; AND NENCKI, M. Die Vorstufen des Harnstoffs im thierischen Organismus. *Ztschr. f. Biol.*, München, Bd. 8, Heft 1, pp. 124-146. 1872.
- (23) SALKOWSKI, E. Ueber den Vorgang der Harnstoffbildung im Thierkörper und den Einfluss der Ammoniaksalze auf denselben. *Ztschr. f. physiol. Chem.*, Strassburg, Bd. 1, Heft 1-2, pp. 1-59. 1877.
- (24) VON KNIERIEM, W. Beiträge zur Kenntniss der Bildung des Harnstoffs im thierischen Organismus. *Ztschr. f. Biol.*, München, Bd. 10, Heft 3, pp. 263-294. 1874.
- (25) FEDER, L.; AND VOIT, E. Zur Harnstoffbildung aus pflanzensauren Ammoniaksalzen. *Ztschr. f. Biol.*, München & Leipzig, Bd. 16, Heft 2, pp. 179-197. 1880.
- (26) LOHRER, JULIUS. Ueber den Uebergang der Ammoniaksalze in den Harn. *Diss.* 37 pp. 8°. Dorpat. 1862.
- (27) MEYER, HANS; AND JAFFÉ, M. Ueber die Entstehung der Harnsäure im Organismus der Vögel. *Ber. d. deutsche chem. Gesellsch.*, Berlin, 10. J., Juli-Dec., pp. 1930-1933. 1877.
- (28) CECCH, C. O. Ueber das Verhalten des Taurins im Organismus der Vögel. *Ber. d. deutsch. chem. Gesellsch.*, Berlin, 10. J., Juli-Dec., pp. 1461-1464. 1877.
- (29) SCHRÖDER, WOLDEMAR. Ueber die Verwandlung des Ammoniaks in Harnsäure im Organismus des Huhns. *Ztschr. f. physiol. Chem.*, Strassburg, Bd. 2, Heft 4, 5. Sept., pp. 228-240. 1878.
- (30) HOPKINS, F. GOWLAND. The chemistry of the urine. In E. A. Schäfer's *Textbook of Physiology*, v. 1, pp. 637-638. Edinburgh & London. 1898.
- (31) BUNGE, G.; AND SCHMIEDEBERG, O. Arbeiten aus dem Laboratorium für experimentelle Pharmakologie zu Strassburg. *Arch. f. exper. Path. u. Pharm.*, Leipzig, Bd. 6, Heft 3-4, 17. Nov., pp. 233-255. 1876.
- (32) JAFFÉ, M. Ueber das Verhalten der Benzoesäure im Organismus der Vögel. *Ber. d. deutsch. chem. Gesellsch.*, Berlin, 10. J., Juli-Dec., pp. 1925-1930. 1877.
- (33) LANG, S. Ueber die Schwefelausscheidung nach Leberexstirpation. *Ztschr. f. physiol. Chem.*, Strassburg, Bd. 29, Heft 4-5, 9. Juni, pp. 305-319. 1900.
- (34) TEICHMANN, MAX. Der Kropf der Taube. *Arch. f. mikr. Anat.*, Bonn, Bd. 34, Heft 2, 30. Oct., pp. 235-247. 1899.
- (35) KLUG, F. Beitr. z. Kenntniss der Verdauung bei Vögeln. Aus dem Hauptbericht des II. Intern. Ornith. Congr. Budapest. 1890. [Reference from *Arch. f. d. ges. Physiol.*, Bd. 80, Heft 11-12. 1900.]
- (36) HUNTER, JOHN. Observations on certain parts of the animal economy. 3 p. 1., 225 pp., 18 pls. 4°. London. 1786.

- (37) HASSE, C. Ueber den Oesophagus der Tauben und das Verhältniss der Secretion des Kropfes zur Milchsecretion. *Ztschr. f. rat. Med.*, Leipzig & Heidelberg, 3 R., Bd. 23, Heft 1-2, pp. 101-132, pls. 7-8. 1865.
- (38) RÉAUMUR. *Histol. de l'Acad. Roy. des Sciences*, 1752, Paris 1756; erste Abhandl., p. 266; zweite Abhandl., p. 461. Zusammenfassung, p. 49. [This reference taken from *Arch. f. d. ges. Physiol.*, Bd. 80, Heft 11-12. 1900.]
- (39) SPALLANZANI. *Versuche über das Verdauungsgeschäft*. Uebersetzt von D. Chr. F. Michaelis. Leipzig. 1785. [Reference from *Arch. f. d. ges. Physiol.*, Bd. 80, Heft 11-12. 1900.]
- (40) TIEDEMANN, F.; AND GMELIN, L. *Die Verdauung nach Versuchen*. 2. Ausgabe. 2 v., 280 pp., 1 l., vi (1 l.), 279 pp. 4°. Heidelberg & Leipzig. 1831.
- (41) WILCZEWSKI, [CARL ANTON] PAUL. *Untersuchungen über den Bau der Magendrüsen der Vögel*. Diss. 30 pp., 1 l. 8°. Breslau. [1870.]
- (42) PAIRA-MALL, L. Ueber die Verdauung bei Vögeln, ein Beitrag zur vergleichenden Physiologie der Verdauung. *Arch. f. d. ges. Physiol.*, Bonn, Bd. 80, Heft 11-12, 13. Juni, pp. 600-627. 1900.
- (43) BERNARD, CLAUDE. *Mémoire sur le pancréas et sur le rôle du suc pancréatique dans les phénomènes digestifs, particulièrement dans la digestion des matières grasses neutres*. *Compt. rend. Acad. d. sc.*, Paris, Suppl. v. 1, pp. 533-534. 1856.
- (44) LANGENDORFF, OSCAR. *Versuche über die Pankreasverdauung der Vögel*. *Arch. f. Anat. u. Physiol.*, Leipzig, *Physiol. Abth.*, Heft 1-2, 18. Apr., pp. 1-35, pl. 1. 1879.
- (45) HEIDENHAIN, R. *Beiträge zur Kenntniss des Pankreas*. *Arch. f. d. ges. Physiol.*, Bonn, Bd. 10, Heft 12, 25. Juni., pp. 557-632, pl. 5. 1875.
- (46) SACC, F. (fils). *Expériences sur les parties constituantes de la nourriture qui se fixent dans le corps des animaux*. *N. Denkschrft. d. allg. schweizer. Gesellsch. f. d. ges. Naturw.*, Neuchatel, Bd. 7, 9 pp., 1845.
- (47) VOIT, C. Ueber den Stickstoff-Kreislauf im thierischen Organismus. *Ann. d. Chem. u. Pharm.*, Leipzig and Heidelberg (1862-63), 2. Suppl.-Bd., Heft 2, 19. Mai, p. 240. 1863.
- (48) WEISKE, H.; AND MEHLIS, Th. Ueber das Verhalten der Rohfaser im Verdauungsapparate der Gänse. *Landwirthsch. Versuchs-Stationen*, Berlin, Bd. 21, p. 415. 1878.
- (49) KALUGIN, J. Ueber die Wirkung feinen Grades auf die Verdaulichkeit der Nährstoffe der Hirse bei Hühnern. *Fühling's landwirtsch. Ztg.*, Leipzig, 46. J., Heft 3, 1. Feb., pp. 85-86. 1897.
- (50) KALUGIN, J. Der Versuch der Bestimmung der Verdauungskoeffizienten der Nährstoffen der Körner bei Hühner. [Russian text.] *Mém. d. l'Inst. agronom. et forestier à Nowo Alexandria, Varshav*, v. 9, livr. 3, pp. 217-257. 1896.
- (51) VON KNIRIEM, W. Der Roggen als Kraftfuttermittel. [Grost's experiments included in this paper.] *Landwirtsch. Jahrb.*, Berlin, Bd. 29, Heft 3, 22. Juni, p. 520. 1900.
- (52) FIELDS, JOHN; AND FORD, A. G. Digestion trials with chickens. *Bull. 46, Oklahoma Agric. Exper. Station, Stillwater*, May, 8 pp. 1900.
- (53) LEHMANN, F. Fütterungsversuche beitr. Ernährung von Geflügel. *Deutsche landwirtsch. Presse*, Berlin, 28. J., No. 39, 18. Mai, pp. 339-340. 1901.
- (54) PARASCHTSCHUK, SIMEON. Die Verdauung des Maïs bei Hühnern. *Journ. f. Landwirtsch.*, Berlin, 50. J., Heft 1, 9. Mai, pp. 15-32. 1902.

- (55) MEYER, HANS. Beiträge zur Kenntniss des Stoffwechsels im Organismus der Hühner. Diss. 33 pp., 1 l. 8°. Königsberg. 1877.
- (56) KIONKA, H. Entstehung und Wesen der "Vogelgicht" und ihre Beziehungen zur Arthritis urica des Menschen. Arch. f. exper. Path. u. Pharm., Leipzig, Bd. 44, Heft 3-4, 14. Juni, pp. 186-206, pl. 1. 1900.
- (57) TSCHERINOW, M. Zur Lehre von dem Diabetes mellitus. Arch. f. path. Anat. [etc.], Bd. 47, 4. F., Bd. 7, Heft 1, 7. Juni, p. 117. 1869.
- (58) PRAUSNITZ, W. Ueber den zeitlichen Verlauf der Ablagerung und des Schwindens des Glykogens. Ztschr. f. Biol., München & Leipzig, Bd. 26, n. F., Bd. 8, pp. 377-413. 1890.
- (59) HERGENHAHN, E. Ueber den zeitlichen Verlauf der Bildung resp. Anhäufung des Glykogens in der Leber und den willkürlichen Muskeln. Ztschr. f. Biol., München & Leipzig, Bd. 27, n. F., Bd. 9, pp. 215-227. 1890.
- (60) PODA, HEINRICH. Eine neue Methode der Trocknung des Koths. Ztschr. f. physiol. Chem., Strassburg, Bd. 25, Heft 3-4, 9. Juli, pp. 355-359. 1898.
- (61) GIES, WILLIAM J. An improved method of preparing and preserving meat for use in metabolism experiments. Amer. Journ. Physiol., Boston, v. 5, No. 4, May 1, pp. 235-239. 1901.
- (62) WILEY, HARVEY W. Principles and practice of agricultural analysis. v. 3, p. 23. Easton, Pa. 1897.
- (63) STUTZER, A. Untersuchungen über die quantitative Bestimmung des Protein-Stickstoffs und die Trennung der Proteinstoffe von anderen in Pflanzen vorkommenden Stickstoff-Verbindungen. Journ. f. Landwirthsch., Berlin, 28. J., Heft 1, pp. 103-123. 1880.
- (64) MALLET, J. W. Report on an investigation of analytical methods for distinguishing between the nitrogen of proteids and that of the simpler amids or amido-acids. Bull. 54, Div. Chem., U. S. Dept. Agric., Washington, 25 pp. 1898.
- (65) CHITTENDEN, R. H.; AND OSBORNE, THOMAS B. A study of the proteids of the corn or maize kernel. Amer. Chem. Journ., Baltimore, v. 13, No. 7, Oct., pp. 453-468; No. 8, Dec., pp. 529-552. 1891. v. 14, No. 1, Jan., pp. 20-44. 1892.
- (66) RICHARDSON, CLIFFORD; AND CRAMPTON, C. A. Vorläufige Mittheilung über die Zusammensetzung des Weizenkeimes und über die Anwesenheit von einer neuen Zuckerart und von Allantoin. Ber. d. deutsch. chem. Gesellsch., Berlin, 19. J., pp. 1180-1181. 1886.
- (67) FRANKFURT, S. Zur Kenntnis der chemischen Zusammensetzung des ruhenden Keims von Triticum vulgare. Landwirthsch. Versuchs-Stationen, Berlin, Bd. 47, Heft 6, p. 453. 1896.
- (68) SCHULZE, E.; AND FRANKFURT, S. Ueber das Vorkommen von Betain und Cholin in Malzkeimen und im Keim des Weizenkorns. Ber. d. deutsch. chem. Gesellsch., Berlin, 26. J., Bd. 2, pp. 2151-2155. 1893.
- (69) BARTLETT, J. M.; AND MERRILL, L. H. [Digestion experiments at Maine Agricultural Experiment Station.] Ann. Rep. Maine State College Agric., Pt. 2, Agric. Exper. Station, Augusta (1888), pp. 195-203. 1889.
- (70) JORDAN, W. H.; AND MERRILL, L. H. The coefficients of digestibility for protein. Ann. Rep. Maine State College Agric. Exper. Station, Bangor (1889), pp. 282-285. 1890.
- (71) BARTLETT, J. M. Digestion experiments. 13th Ann. Rep. Maine Agric. Exper. Station, Augusta, (1897), p. 155. 1898.

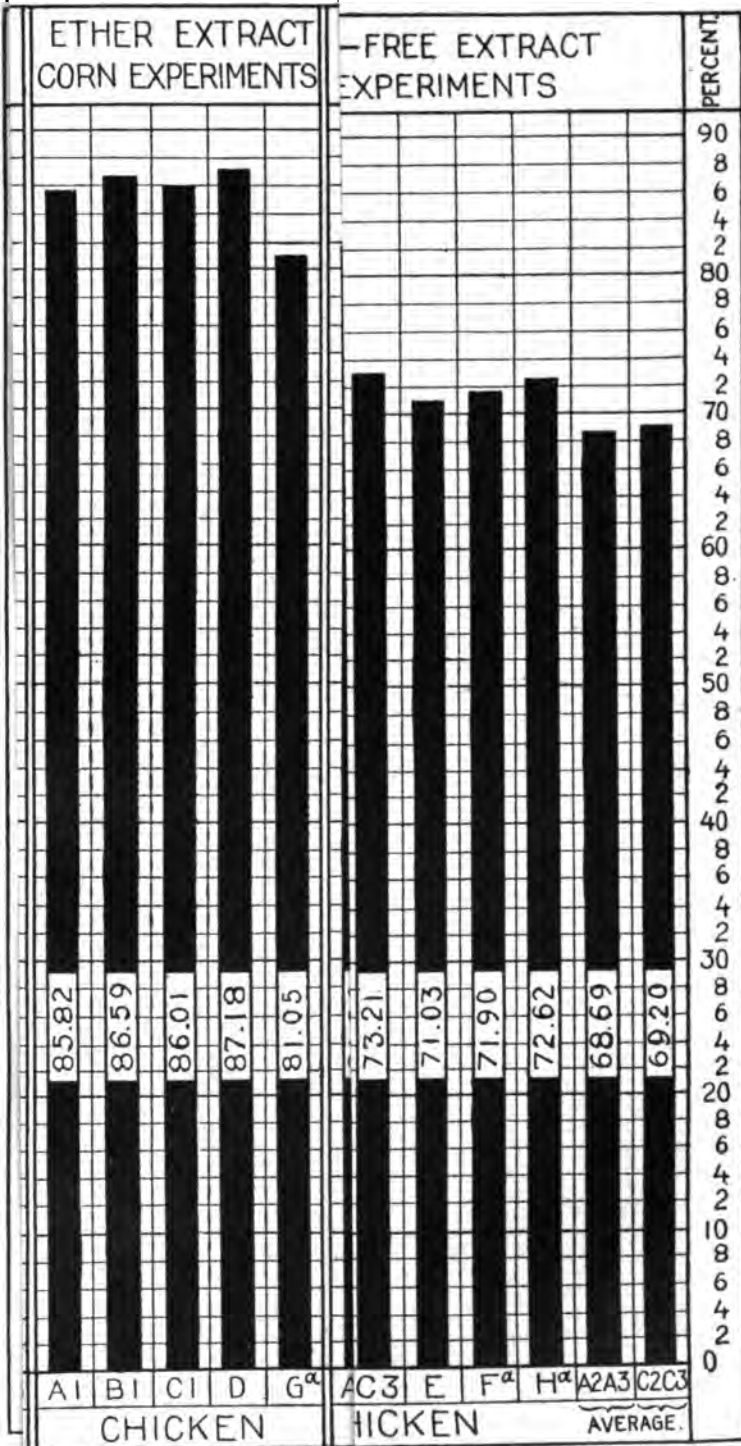
- (72) PATTERSON, H. J. Report of the chemist. 4th Ann. Rep. Maryland Agric. Exper. Station, Annapolis, (1891), p. 309. 1892.
- (73) HIS, WILHELM, JR.; AND PAUL, THEODOR. Physikalisch-chemische Untersuchungen über das Verhalten der Harnsäure und ihrer Salze in Lösungen. Ztschr. f. physiol. Chem., Strassburg, Bd. 31, Heft 1-2, 27. Nov., pp. 1-42, 64-78. 1900.
- (74) VON KNIERIEM, W. Ueber das Verhalten der im Säugethierkörper als Vorstufen des Harnstoffs erkannten Verbindungen zum Organismus der Hühner. Ztschr. f. Biol., München, Bd. 13, Heft 1, pp. 36-79. 1877.
- (75) NEUBAUER AND VOGEL. Anleitung zur qualitativen und quantitativen Analyse des Harns zum Gebrauche für Mediciner, Chemiker und Pharmaceuten. Zehnte umgearbeitete und vermehrte Auflage. Analytischer Theil. In dritter Auflage bearbeitet von Dr. H. Huppert, p. 820. 8°. Wiesbaden. 1898.
- (76) HOPKINS, F. GOWLAND. On the estimation of uric acid in urine. Journ. Path. and Bacteriol., Edinburgh and London, v. 1, No. 4, June, pp. 451-459. 1893.
- (77) JOLLES, ADOLF. Ueber eine neue zuverlässige Methode zur quantitativen Bestimmung der Harnsäure im Harne. Ztschr. f. physiol. Chem., Strassburg, Bd. 29, Heft 3, 3. Apr., pp. 222-248. 1900.
- (78) JOLLES, ADOLF. Ueber die quantitative Bestimmung der Harnsäure im Harn. Ztschr. f. physiol. Chem., Strassburg, Bd. 33, Heft 5-6, 31. Okt., pp. 542-546. 1901.
- (79) TUNNICLIFFE, F. W.; AND ROSENHEIM, OTTO. Eine neue Methode der quantitativen Harnsäurebestimmung auf volumetrischem Wege. Centralbl. f. Physiol., Leipzig & Wien, Literatur 1897, Bd. 11, No. 14, 2. Oct., pp. 434-437. 1897.
- (80) KIONKA, H. Zur Kenntniss des Stoffwechsels fleischgefütterter Hühner. Arch. internat. d. Pharmacod. et d. Thérap., Gand & Paris, v. 7, fasc. 1-2, pp. 55-64. 1900.
- (81) METHODS of analysis adopted by the Association of Official Agricultural Chemists, Nov. 11, 12, and 14, 1898. Edited by Harvey W. Wiley. Bull. 46, revised ed., Div. Chem., U. S. Dept. Agric., Washington, 86 pp. 1899.
- (82) NEUBAUER AND VOGEL. Anleitung zur qualitativen und quantitativen Analyse des Harns zum Gebrauche für Mediciner, Chemiker, und Pharmaceuten. Zehnte umgearbeitete und vermehrte Auflage. Analytischer Theil. In dritter Auflage bearbeitet von Dr. H. Huppert. p. 742. 8°. Wiesbaden. 1898.
- (83) JORDAN, WHITMAN H.; AND HALL, FRANK H. The digestibility of American feeding stuffs. Bull. 77, office of Exper. Stations, U. S. Dept. Agric., Washington, p. 89. 1900.
- (84) ST. WEISER AND ZAITSCHEK, A. Beitrag zur Kenntniss der chemischen Zusammensetzung und Bildung des Gänsefettes. Arch. f. d. ges. Physiol., Bonn, Bd. 93, Heft 3-4, 3. Dec., pp. 128-133. 1902.
- (85) BARTLETT, J. M.; AND MERRILL, L. H. [Digestion experiments at Maine Agricultural Experiment Station.] Ann. Rep. Maine State College Agric., Pt. 2, Agric. Exper. Station, Augusta, (1888), p. 98. 1889.
- (86) LADD, E. F. Report of the chemist. 8th Ann. Rep. Bd. Control N. York, Agric. Exper. Station, Albany, (1889), p. 149. 1890.

- (87) FRAPS, G. S. The digestibility of some non-nitrogenous constituents of certain feeding stuffs. Ann. Rep. No. 23, North Carolina Agric. Exper. Station, West Raleigh, (1899-1900), June 30, pp. 49-68. 1900.
- (88) SHERMAN, H. C. The insoluble carbohydrates of wheat. Journ. Amer. Chem. Soc., Easton, Pa., v. 19, No. 4, Apr., pp. 291-316. 1897.
- (89) ST. WEISER AND ZAITSCHEK, A. Beiträge zur Methodik der Stärkebestimmung und zur Kenntniss der Verdaulichkeit der Kohlenhydrate. Arch. f. d. ges. Physiol., Bonn, Bd. 93, Heft 3-4, 3. Dec., pp. 98-127. 1902.
- (90) CROSS, C. F.; BEVAN, E. J.; AND REMINGTON, J. S. On the digestion and assimilation of pentoses and furfuroids. Journ. Amer. Chem. Soc., Easton, Pa., v. 22, No. 10, Oct., pp. 630-634. 1900.
- (91) WOLFF, EMIL. Rationelle Fütterung der landwirtschaftlichen Nutztiere auf Grundlage der neueren tierphysiologischen Forschungen. 7. Aufl., neu bearbeitet von Curt Lehmann. pp. 241-245. 12°. Berlin. 1899.
- (92) ST. BONDZYŃSKI AND HUMNICKI, V. Ueber das Schicksal des Cholesterins im thierischen Organismus. Ztschr. f. physiol. Chem., Strassburg, Bd. 22, Heft 4-5, 3. Dec., pp. 396-410. 1896.
- (93) PFLÜGER, E. Ueber die Gesundheitsschädigungen, welche durch den Genuss von Pferdefleisch verursacht werden. Arch. f. d. ges. Physiol., Bonn, Bd. 80, Heft 3-5, 4. Mai, pp. 111-138. 1900.
- (94) PFEIFFER, TH. Die Bestimmung des Stickstoffs der Stoffwechselprodukte. Ztschr. f. physiol. Chem., Strassburg, Bd. 10, Heft 6, pp. 561-576. 1886.
- (95) SZUMOWSKI, W. Zein als Nährstoff. I. Mittheilung. Ztschr. f. physiol. Chem., Strassburg, Bd. 36, Heft 2-3, 6. Sept., pp. 198-218, pl. 3. 1902.
- (96) SNYDER, HARRY. The digestibility of wheat. Bull. 36, Minnesota Agric. Exper. Station, Delano, Nov., pp. 146-148. 1894.
- (97) JORDAN, WHITMAN HOWARD. The feeding of animals. p. 393. 12°. New York. 1901.
- (98) Idem. pp. 436-438.
- (99) Idem. pp. 387-388.
- (100) Idem. p. 324.
- (101) Idem. p. 359.
- (102) RICE, JAMES EDWARD. The effect on fowls of nitrogenous and carbonaceous rations. Bull. 25, Agric. Exper. Station, Cornell Univ. College of Agric., Ithaca, Dec., p. 163. 1890.
- (103) SMITH, CLINTON D.; AND BROOKS, C. S. Some experiments with poultry. Bull. 158, Michigan State Agric. College Exper. Station, May, pp. 329-344. 1898.
- (104) SMITH, CLINTON D. Report of the agriculturist. 9th Ann. Rep. Michigan State Agric. College Exper. Station, p. 109. 1896.
- (105) DRYDEN, JAMES. Poultry experiments. Bull. 67, Exper. Station Agric. College Utah, Logan, Apr., p. 142. 1900.
- (106) BROOKS, WM. P.; AND THOMSON, H. M. Report of the agriculturist. 11th Ann. Rep. Hatch Exper. Station Massachusetts Agric. College, Boston, Pub. Doc. No. 33, Jan., p. 93. 1899.
- (107) STEWART, J. H.; AND ATWOOD, HORACE. Poultry experiments. Bull. 60, W. Virginia Agric. Exper. Station, Morgantown, June, pp. 49-64. 1899.
- (108) WHEELER, W. P. The economy of using animal food in poultry feeding. Bull. 149, N. York Agric. Exper. Station, Geneva, Dec., pp. 229-248. 1898.

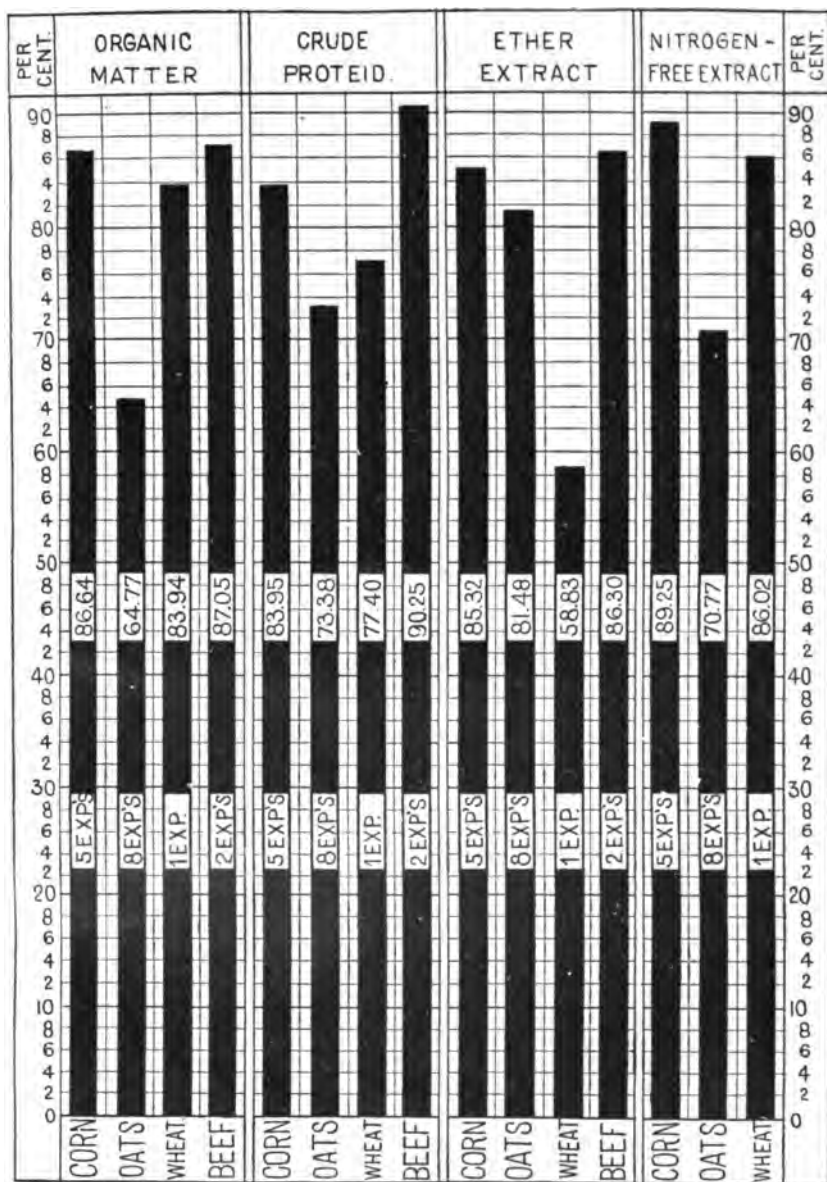
- (109) HALL, F. H.; AND WHEELER, W. P. What grains lack as poultry foods. Bull. 171, N. York Agric. Exper. Station, Geneva, pop. ed., Dec., 6 pp. 1899.
- (110) MALLET, J. W. The physiological effect of creatin and creatinin, and their value as nutrients. Bull. 66, Office of Exper. Stations, U. S. Dept. Agric., Washington, 24 pp. . 1899.
- (111) BEILSTEIN, F. Handbuch der organischen Chemie. . 3. Aufl., Bd. 1, p. 1290. (4^e.) Hamburg & Leipzig. 1893.
- (112) BONGERS, [IMMANUEL AUGUST] PAUL. Ueber Synthesen im Organismus der Vögel. Diss. 1 p. l., 23 pp., 2 l. 8°. Königsberg i. Pr. 1887.
- (113) JAFFÉ, M.; AND CORN, RUD. Ueber das Verhalten des Furfurols im Stoffwechsel der Hühner. Ber. d. deutsch. chem. Gesellsch., Berlin, Bd. 21, Juli-Dec., pp. 3461-3465. 1888.
- (114) CHRISTIANI, ARTHUR. Ueber das Verhalten von Phenol, Indol und Benzol im Thierkörper. Ztschr. f. physiol. Chem., Strassburg, Bd. 2, Heft 4, 5. Sept., pp. 273-287. 1878.
- (115) SCHARY EDUARD. Beiträge zur Kenntniss des Stoffwechsels im Organismus der Vögel. Diss. 33 pp., 1 l. 8°. Königsberg. 1878.
- (116) PEUROSCH, BERTHOLD. Beiträge zur Lehre über die Entstehung des Indicans im Thierkörper. Diss. 32 pp., 1 l. 8°. Königsberg. 1877.
- (117) MÖRNER, K. A. H.; AND SJÖQUIST, J. Eine Harnstoffbestimmungsmethode. Skandin. Arch. f. Physiol., Leipzig, Bd. 2, Heft 6, 20. Jan., pp. 438-487. 1891.
- (118) SALKOWSKI, E. Ueber das Vorkommen von Allantoin im Harn nach Fütterung mit Pankreas. Centralbl. f. med. Wissensch., Berlin, Bd. 36, No. 53, 31. Dec., pp. 929-930. 1898.
- (119) MENDEL, LAFAYETTE B.; AND BROWN, ERNEST W. Observations on the nitrogenous metabolism of the cat, especially on the excretion of uric acid and allantoin. Amer. Journ. Physiol., Boston, v. 3, No. 6, Jan. 1, pp. 261-270. 1900.
- (120) CAPALDI, ACHILLE. Ein Verfahren zur quantitativen Bestimmung der Kynurensäure. Ztschr. f. physiol. Chem., Strassburg, Bd. 23, Heft 1, 27. März, pp. 92-98. 1897.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF ANIMAL INDUSTRY—BULLETIN NO. 57.

D. E. SALMON, D. V. M., Chief of Bureau.

STUDIES UPON THE

KEEPING QUALITY OF BUTTER.

I.—CANNED BUTTER.

BY

LORE A. ROGERS,

Expert in Dairy Bacteriology, Bureau of Animal Industry.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1904.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., January 12, 1904.

SIR: I have the honor to transmit herewith a manuscript entitled "Studies upon the keeping quality of butter," by Mr. Lore A. Rogers, expert in dairy bacteriology. This paper deals with the particular feature of changes occurring in canned butter, but a second paper will soon be submitted on the subject of packed butter. I recommend that the manuscript herewith transmitted be published as a bulletin in the series of this Bureau.

Respectfully,

D. E. SALMON, *Chief of Bureau.*

Hon. JAMES WILSON, *Secretary.*

Dy.—50.

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THE KEEPING QUALITY OF BUTTER.

I.—CANNED BUTTER.

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In taking up the study of abnormal changes in butter, the possible decomposition of three groups of chemical compounds must be considered.

The sugar, which has already been partly fermented during the ripening of the cream, breaks up most readily into lactic and similar acids, which, without giving the butter any unpleasant taste, protect it from other fermentations by preventing the growth of bacteria less resistant to these acids than the group of bacteria by which they were produced.

In addition to the sugar there is in the butter a small amount of casein and, in solution in the water, albumen, together with small quantities of the decomposition products of these two proteids. The curd is made up by the insoluble casein, and all are usually grouped together in the chemical analyses under the heading "casein," or "nitrogenous constituents." Under ordinary circumstances this group is subject to decompositions of a widely varying nature. In butter, however, the growth of the putrefactive bacteria, through whose agency these changes are usually brought about, is checked by the presence of the lactic acid which has been produced by the fermentation of the sugar. Under certain circumstances, as for instance, an imperfect ripening of the cream, the nitrogenous constituents may undergo an active decomposition, with a consequent spoiling of the product. This is probably a more unusual trouble than is generally believed and is easily distinguished from the more common troubles caused by changes in the fat.

The third substance, the fat, which makes up between 80 and 90 per cent of the butter, is not a single compound, but a mixture of a considerable number of closely related but distinct fats. These fats, or glycerides, which are formed by the chemical union of a fatty acid with glycerine, when mixed in the proportion found in butter, have an agreeable taste and smell. These glycerides are

somewhat unstable, and some of them are easily decomposed. The fatty acids, while classed with the weakest of the organic acids, are characterized by their peculiar pungent odor and taste. When, through any abnormal fermentation, one or more of these glycerides is broken down, the fatty acid is set free, and, even though it may be present in very small quantities, it gives the butter a peculiar disagreeable flavor varying probably in its nature and intensity with the kind and amount of the acid liberated.

The "off" flavors found in butter present all gradations between the indistinct "not fresh" flavor and the great variety of disagreeable odors and tastes which are sometimes indiscriminately designated by the term "rancidity." As in all questions relating to flavors, it is very difficult to find two persons agreeing on just what constitutes "rancidity." Some investigators have understood rancidity to mean any change from the normal, while others use the term to designate only the "off" flavors caused by a certain amount of free fatty acid. A great variety of opinion may be found on this subject. In this paper the term "rancidity" is not used, partly because of this difference of opinion and partly because few, if any, of the butters mentioned here had reached a state of decomposition that most investigators and dairy-men would consider as rancidity.

The question of the decomposition of butter fat has received more or less attention, but until recently has been surrounded with considerable obscurity. The decomposition has been ascribed by different investigators to various causes, particularly to oxidation, warmth, moisture, light, and microorganisms. Ritser¹^a showed that fat in sealed tubes, both in darkness and in sunlight, remained unchanged, while samples exposed to both air and sunlight absorbed oxygen and became rancid. Schmidt² showed that butter made from pasteurized cream and protected from air, light, and warmth remained fresh, while the same butter exposed to air, light, and warmth rapidly became rancid. Von Klecki³ ascribes to fat-splitting bacteria the principal rôle in the decomposition of butter, and shows that 4 per cent sodium fluoride prevents the formation of acid. Browne⁴ states that the factors most active in the decomposition of pure butter fat are air, light, and warmth. Microorganisms are excluded, as the work of Ritser¹ has shown that bacteria will not grow in pure fat. Laxa,⁵ Schreiber,⁶ Koenig, and Spiechermann and Bremer⁷ have demonstrated the ability of certain microorganisms, especially the molds, to break up fats with the liberation of free acid. While this work has contributed much valuable information on the nature of the changes in butter, the explanations offered for these changes have been insufficient to explain them fully or have not been supported by proper proofs.

^a Figures refer to bibliography at end of bulletin.

A recent work by Jensen⁸ does much to harmonize the conflicting views of the earlier workers and proves conclusively the causal relation of organisms to the ordinary decomposition. He found that while butter exposed to sunlight was distinctly oxidized, it was only slightly hydrolized. On the other hand, unsterilized butter held in darkness at room temperature was not oxidized, but the acidity was materially increased. In sunlight the bacteria decreased rapidly, while in the portion held in darkness they reached high numbers, but dropped to the extent of 4,000,000 to 7,000,000 per gram at the end of four weeks. In unsterilized butter at room temperature, the acidity increased much more rapidly when it was exposed to the air, beginning first in the outer layer and gradually extending inward.

In the inner part of the butter, the lactic acid bacteria and the yeasts multiplied for a short time, but soon began to decrease; liquefying bacteria and *Oidium lactis* decreased from the beginning. In the surface layer there occurred, in correspondence with the increase of acidity, an increase of short duration of *Bacillus fluorescens liquefaciens*, and often also *B. prodigiosus*; *Oidium lactis*, *Cladosporium butyri*, and yeasts grew much more slowly, but soon suppressed all others. In butter kept under anaerobic conditions, these forms decreased rapidly, and the flora was soon made up exclusively of lactic acid bacteria and yeasts. The acidity increased only slightly. In a portion protected from the air, the "degree of acidity" increased in ten weeks only from 3.0 to 9.0. By inoculations made in sterile cream butter, Jensen shows that, of the various organisms occurring in butter, only *Bacillus fluorescens liquefaciens*, *Oidium lactis*, and *Cladosporium butyri* were able distinctly to increase the acidity of butter. He thus shows that the action of the air is only indirect in that it does not itself increase the acidity of the butter, but only supplies oxygen to the aerobic organisms which bring about the increase in acidity.

Jensen's results explain very satisfactorily the decomposition of European butter, which is usually put up in small packages with a considerable surface more or less exposed to the air. However, his conclusions can hardly be applied to American butter which is packed, as a large part of it is, in large tubs with a relatively small area exposed to the air. They certainly will not explain the changes in canned butter. This butter is ordinarily put up when perfectly fresh in small cans containing one-half to 3 pounds, completely filled and hermetically sealed. The very small amount of oxygen left would doubtless be quickly used up by the large number of lactic acid bacteria normally present in fresh butter, thus creating a condition under which the aerobic organisms mentioned by Jensen would be unable to live.

The cans usually have the packers' statement that, since they are hermetically sealed, the contents will keep indefinitely, a statement that

would be correct if all oxygen were absolutely excluded and strictly aerobic organisms were the only cause of the decomposition of fat. That this is not entirely true is conclusively proved by the condition of canned butter after keeping it a few months in a warm climate.

THE CONDITION OF OLD CANNED BUTTER.

When this work was started, there were in the Dairy Division of the Bureau of Animal Industry a number of cans of domestic canned butter collected by agents of the division in China, the Philippines, Cuba, and Porto Rico. In most cases the history of the individual cans was not known, further than the place of manufacture and sale, but nearly all had been at the Washington office for about one year. Notwithstanding the fact that the seals were intact, all of these butters showed more or less decomposition. The texture was usually pasty, the aroma somewhat acid and penetrating, the taste, while not what is usually described as rancid, was a disagreeable, biting flavor, corresponding more closely with the so-called "fishy" flavor. The intensity of the "off" flavor varied considerably in the different samples, but none of these butters was fit for use. The acid numbers of a few of these butters are here given:

TABLE I.—*Acid number of old canned butter.*^a

Sample number.	Acid number.
19	2.6
21	4.7
62	6.1
63	6.0

^aMethod given by Association of Official Agricultural Chemists.

The increase of the acid number above the normal (0.4 to 0.8) was distinct but relatively small when the age of the samples is considered. The iodine number was not determined. Bacteriological examinations were made of a large number of these cans, but, as would be expected, with negative results. Gelatin plates, both aerobic and anaerobic,^a developed only a very few bacterial colonies, while molds and related groups appeared so infrequently that they could be considered entirely as contaminations. A large percentage of the bacterial colonies were persistent spore-forming species, frequently of the liquefying hay bacillus type. It would, indeed, be surprising if any but the spore-forming varieties were found in a medium containing the amount of free acid usually present in these butters.

^a Aerobic plates are those so arranged that there is a free access of air to the growing colonies. Anaerobic plates, on the other hand, are held in an atmosphere of an inert gas, such as hydrogen or nitrogen, to allow the development of bacteria which are unable to grow in the presence of free oxygen.

CAUSES OF THE INCREASE IN ACIDITY.

(a) PHYSICAL AND CHEMICAL AGENTS.

As has already been noted, many of the earlier writers considered certain physical and chemical agents as important factors in the decomposition of fats. On account of the peculiar conditions under which the butter under consideration is held, only two of these agents—warmth and moisture—can be considered. Light is, of course, excluded, and the effect of oxygen is doubtless reduced to a minimum.

Browne¹⁰ states that the three factors most active in the decomposition of pure butter fat are air, light, and warmth, but that the decomposition may go on slowly if one or even two of these factors are suppressed. Berthelot¹¹ has shown that fat is broken up when exposed with water to high temperatures, and he thought that this action might go on slowly at ordinary temperatures. That the action is not perceptible at ordinary temperatures is shown by Table II. No. I was a mixture of 20 c. c. of sterile milk and 125 c. c. of butter fat. The action of bacteria was prevented by holding it at 47° C. No. II was a flask of butter partially sterilized by holding thirty minutes in a steam bath and with the action of bacteria prevented by the addition of thymol in the proportion of 1:100.

TABLE II.—*Influence of physical and chemical agents.*

	Acid number.		
	Initial.	29 days.	49 days.
I. Sterile butter fat and milk at 47° C.....	0.6	0.7	0.9
II. Sterile butter at 23° C.....	1.1	1.2	1.2

In the earlier part of this work thymol was used because it is usually considered efficient in small quantities, and with most enzymes its inhibitory effect is less than that of formaldehyde. However, on account of its tendency to combine with fat and its slight solubility in water, it is not always efficient in fatty mixtures in proportions greater than 1:200. In this work its antiseptic effect was tested in all cases by bacteriological examinations. Formaldehyde was substituted because, while it has been shown by Kastle and Loevenhart to have little or no effect on lipase, it is an efficient germicide in very small quantities, does not unite with fat, and is readily soluble in water.

In the fat held at the higher temperature there was a questionable small increase of acidity, while at 23° C. the change was within the limits of experimental error. Similar results were obtained from butter made under laboratory conditions from cream which had been held fifteen minutes at 70° C. The usual precautions were taken to

prevent contamination, and the butter sealed in small tubes was held at 23° C. At the end of one hundred days the acid number remained unchanged.

It is therefore evident that the decomposition of butter held under anaerobic conditions is due, not to the action of physical agents, but to some factor which is eliminated or destroyed by a comparatively low temperature. The nonspore-forming organisms and the fat-splitting enzymes are the only known factors which could be included in this class.

The fat-splitting enzyme, or group of enzymes, while it has received comparatively little attention, doubtless plays a very important part in the nutrition of both plants and animals. It is a soluble body of unknown chemical composition, excreted by certain cells or organs, and transforms fats into compounds suitable to be utilized. In the higher plants it transforms the insoluble oily and fatty reserve food into soluble acids and glycerin that may be transported by the sap to the point of growth. An enzyme may act for an indefinite time on a proportionally large amount of material without loss of matter or energy. A small amount of a fat-splitting or lipolytic enzyme if present in butter might, in the course of time, liberate an appreciable amount of acid and destroy the desirable flavor of the butter.

(b) THE DIRECT ACTION OF CELLS.

If bacteria or other microorganisms are responsible for the changes in these butters, it is probable that they will be found only while the butter is comparatively fresh. We have seen, at least, that they were not present after the decomposition was well advanced. For the purpose of making a biological study of freshly canned butter one dozen cans were obtained from a factory in Iowa. These were all from one churning of butter, packed while fresh, in the usual way, in 1-pound tin cans, and shipped at once in a refrigerator car. They were seven days old when received, and were probably only slightly changed. The temperature of the laboratory where they were stored was, of course, subject to more or less variation, but most of the time was above 20° C. The condition of the butter is given in the following table:

TABLE III.—*Showing progressive change in canned butter. (Series 5.)*

Can No.—	Age in days.	Acid number.	Conditions.
5	7	.....	Flavor and aroma good.
7	18	.....	Not noticeably changed.
8	25	1.0	Slight "off" flavor.
9	32	1.2	Distinct "off" flavor.
10	91	2.1	Distinct fishy flavor.
11	116	2.7	Disagreeable taste; texture pasty.
12	297	3.8	Disagreeable, fishy flavor; penetrating odor.

There was a slow but gradual change in the flavor and general appearance of the butter; an "off" flavor could be detected when it was twenty-five days old, and at the end of thirty-two days it had become quite decided; at one hundred and sixteen days the texture was soft and pasty, the aroma strong, and the taste disagreeable.

It will be noticed that the increase in the acid number corresponded, in a general way, both in this series and in series 22, Table V, with the progressive change in flavor.

Aerobic and anaerobic lactose gelatin plates were made from time to time, a new can being opened for each examination. There was apparently no difference between the aerobic and anaerobic plates except that the numbers were usually smaller on the anaerobic set. Yeasts and similar organisms were determined by adding to gelatin sufficient tartaric acid to inhibit the growth of bacteria without preventing the development of yeast colonies.

TABLE IV.—*Bacteria and yeasts per gram of butter. (Series 5.)*

Age in days.	Total.	Lactic.	Liquefiers.	Torula yeasts.
7	5,351,130	5,326,100	.....	24,550
11	3,012,600	2,823,600	6,000	188,000
18	92,700	84,200	.....	8,500
25	12,460	12,000	460	Very few.
91	18,350	17,850	500	00
116	675	00	200	00
α 297	.....	.....	.....	.....

α Sterile.

It is evident that at the time the first examination was made the butter was considerably past its maximum bacterial content, as the total had already dropped to a comparatively low number. As is the case with ordinary butter, the lactic bacteria made up over 99 per cent of the total number and decreased somewhat rapidly until, when examined at one hundred and sixteen days old, they had completely disappeared. Bacteria of the liquefying group were present in small numbers and, while they decreased somewhat, were more persistent than the other forms on account of the high percentage of spore-formers. There were present, in addition to the three groups enumerated in the table, a small and varying number of inert bacteria, which were not accurately counted because of the difficulty in distinguishing their colonies from the other forms, especially from the lactic group. A large number of cultures were made from each class of bacteria, with the hope of finding some form that would account for the change in the butter, but a large part of them proved to be merely slow acid formers, and none were found capable of changing butter fat. On the first set of plates there occurred a few colonies of a yeast-like hyphæ-forming fungus, probably belonging to the *Oidium* group, but this did not appear again.

The only feature of the flora that could be considered peculiar was the presence in considerable numbers of the *Torula*^a yeast group. The negative character of this class of organisms makes it difficult to say definitely if one or several species were present, but in this case the entire group seemed to be made up of one species, distinguished by its small elliptical cells and possessing, in common with other *Torulas*, the tendency to form, on gelatin, small round white or straw-colored colonies, differing from the lactic colonies only in being slightly larger.

The first set of plates did not contain sufficient acid to inhibit all of the lactic forms completely; consequently the numbers given are not accurate and the apparent increase in the first few days may not be a real one. Like the other nonspore-bearing forms, this group decreased quite rapidly and had almost entirely disappeared in twenty-five days. The species of *Torula* predominating in this set of butters was recorded in the laboratory as "111 f," but, for convenience, it will be designated as "T" in this report.

For the purpose of confirming these results, and especially to determine if T was a normal inhabitant of canned butter, a second lot of butter was obtained from the same creamery. These cans were packed in September, 1902, from the same churning of fresh butter, and shipped at once in a refrigerator car. They were seven days old when received. For seventy-three days after they arrived they were stored in the laboratory, and at the end of this time were transferred to an incubator held at a constant temperature of 23° C. The following table gives the condition and acid number of each can at the time it was opened:

TABLE V.—*Showing progressive change in canned butter. (Series 22.)*

Can No.—	Age in days.	Acid number.	Condition.
22	7	0.4	Flavor clean; texture good.
23	10	0.4	Slight, sharp after-taste.
24	14	0.4	Rather sharp but not distinctly "off."
25	21	0.8	Not distinctly "off."
26	38	1.1	Slight fishy flavor.
27	114	2.0	Disagreeable taste; texture tallowy.
28	251	3.4	Distinct but not strong fishy flavor; sharp odor.

^a In consideration of the present unsettled position of this group in its relation to other plants, it may be well to state that in this paper the classification of Hansen¹¹ is followed. He includes in this group those organisms which multiply by budding but do not, like the true yeasts, form spores. The formation of films on the surface of fluid media, while common among the true yeasts, or *Saccharomycetes*, is infrequent among the *Torulas*. It seems probable that the *Torulas* may be only the spore stage, or perhaps degeneration forms, of some of the higher fungi, but for the present it is convenient to classify them with the yeasts.

The butter in this series changed in the same general way as that of series 5, although the change was somewhat slower. In a few days it had the taste and appearance of butter not perfectly fresh, but was without the flavor peculiar to canned butter in the early stages of decomposition. In the can opened when thirty-eight days old, there was the typical "fishy" flavor, and No. 27 had the disagreeable biting taste usually encountered in the old canned butters previously examined. For the first week after removal from cold storage there was no appreciable change in the acidity, and even at the end of two hundred and fifty days the acid number was only seven or eight times that of normal butter. The results of the bacteriological examinations follow, made, as before, at the time each can was opened:

TABLE VI.—*Bacteria and yeasts per gram of butter. (Series 22.)*

Age in days.	Total.	Lactic.	Liquefiers.	Torula yeasts.
7	362,000	318,000	21,000	23,000
10	194,100	173,500	3,800	17,800
14	125,000	122,300	2,400	300
21	23,600	23,040		560
114	200	00	150	00
a 251				

a Only very few liquefiers.

The results agree quite closely with those of series 5, except that the butter was more advanced when received and the numbers in all the groups were considerably smaller. This was probably caused by a somewhat higher temperature in transit. The *Torula* group was apparently made up, as before, of the T type.

A third sample of canned butter, while it was not fresh at the time it was examined, was still in the early stages of its decomposition. The original source of the butter was not known, but it had been stored in wood since the summer of 1902 as "Extra June Creamery," and was bought and packed in 3-pound tin cans for the Navy Department in the following February or March. The can examined had been in the Dairy Division at room temperature since repacking.

At the time the butter was packed in tin it was examined by an agent of the Dairy Division and was then in good condition. This can, while not badly "off," had the peculiar fishy flavor of canned butter. It had an acid number of 1.3. Acid gelatin plates developed a few colonies of a *Torula* yeast, differing morphologically from T but agreeing with it in being able to split butter fat.

A fourth lot of canned butter, consisting of 3-pound tins, from a quantity packed for the Navy Department under the general supervision of the Dairy Division, was received when only a few days old

and held at 23° C. The results of the examination of three of these cans are given in the next table:

TABLE VII.—*Changes in butter of series 66.*

Age in days.	Acid No.	Condition.
7	0.5	Flavor fair.
19	0.5	Not fresh, but not distinctly "off."
29	1.4	Slightly "off" flavor.

This change agrees with that of the two lots given in Tables III and V. At the time the first examination was made the lactic acid bacteria had already dropped to less than 1,000,000 per gram. There were in each of these three cans a few hundred yeasts per gram, divided among four or five species. Of these, two were able to develop acidity in butter fat, but both belonged to the *Oidium* class and occurred in small numbers only. There were one or two species of *Torula*, but none of those isolated was able to decompose fat.

It is quite evident that the microscopic life existing in the butter can be considered as only indirectly responsible for the change in the acidity or the flavor. In series 22 there was no perceptible change in the acid number until the bacteria had reached unimportant numbers and the yeasts had nearly disappeared. In series 5, in which the acidity was not determined in the first few cans opened, there was no marked change until both bacteria and yeasts had nearly reached their minimum number. Of the bacteria persisting for any length of time only the lactic group was present in sufficient numbers to be considered as a possible cause. No member of the group has ever been reported as having a fat-splitting ability, and none of those isolated from these samples was able to increase the acidity of butter fat. As will be shown more fully in another section, the *Torula* T may decompose fat slowly. Assuming that this species is always present in freshly canned butter in considerable numbers, and that it is able to liberate fatty acid by the direct metabolism of its cells, the real change could not be accounted for in this way. Even after the yeasts have entirely disappeared and the bacteria have been reduced until practically nothing remains but resistant spore-forming species, the increase in acidity goes on slowly and steadily, accompanied by a corresponding change in the flavor, aroma, and texture.

This brings us to a consideration of the lipolytic, or fat-splitting, enzymes. It is indeed difficult to understand how fats could be utilized by a vegetable cell without being first broken up into more soluble compounds through the agency of an enzyme.

(c) LIPOLYTIC ENZYMES.

It is probable that there was in these canned butters an enzyme with a weak hydrolyzing action. The presence of an enzyme of this type would offer a very satisfactory explanation of the slow change that goes on after the butter has become practically sterile. If this hypothesis is a correct one, butter that had been heated sufficiently to destroy the enzyme should remain unchanged, while in butter in which the action of microorganisms is eliminated by the addition of a suitable antiseptic the decomposition should go on normally, or at least should be only slightly checked. Table VIII gives the results of a series arranged to determine if lipolytic enzymes were present in canned butter. In making up this set, butter from a can of series 5 was melted at 50° C., and six 50 c. c. Erlenmeyer flasks were completely filled. Two of these were sealed without heating or the addition of antiseptic, to two others was added thymol in the proportion of 1:100, and two others were heated in a steam bath thirty minutes and thymol added as in the second pair. Gelatin plates made when the flasks were opened showed that the butter was practically sterile.

In preserving milk or its products with antiseptics it is rarely possible to secure complete sterilization, even in long periods of time, on account of the large number of resistant spore-bearing bacteria normally present in milk. The presence of a few colonies of bacteria of this class on plates made from butter containing an antiseptic indicates that growth was prevented but that the spores originally present were not destroyed.

All of these flasks were held at 23° C., and one flask from each set was examined at twenty-seven and at fifty-four days.

TABLE VIII.—*Test for presence of lipolytic enzyme in canned butter.*

Age in days.	Acid number.		
	Not heated; no antiseptic.	Not heated; antiseptic.	Heated; antiseptic.
Initial.	1.1	1.1	1.1
27	1.4	1.4	1.2
54	1.6	1.6	1.2

An examination of this table shows that the liberation of fatty acids was not checked by the addition of the antiseptic, but, on the other hand, the change was largely inhibited by heating the butter. In other words, the decomposition was brought about, not by the action of chemical or physical agents which would not be affected by the heating, nor by the activity of microorganisms which would be excluded by the addition of antiseptic, but probably by an enzyme unaffected by the antiseptic but destroyed by the heat.

Enzymes of the lipolytic class occur widely distributed in nature, having been found in many organs and secretions of the body, in plants, especially in germinating seeds having a high oil content, and in some of the molds.

An enzyme could be produced in butter in one or both of two ways: (1) It might be produced in the milk or butter itself by microorganisms, or (2) it might be secreted in the udder with the milk and carried over into the butter.

(1) *Enzymes from microorganisms*.—Of the plants known to produce lipase, only the molds and certain bacteria are found in butter. By filtering milk cultures of *Bacillus fluorescens liquefaciens* and *Oidium lactis* through a Chamberland filter and adding the filtrate to butter fat, Jensen⁶ obtained a slight increase in the acid number, due, he thinks, to the presence of lipase. These two, as well as the true molds, in which the secretion of lipase is known to be quite common, are aerobes and should not exist in butter after it is canned. None of this class of organisms was found in appreciable numbers in any of the canned butters examined.

Many bacteria isolated from series 5 and 22 were tested in various ways for fat-splitting ability, but with negative results. On the other hand, the predominating yeast, T, was found to have a weak but distinct lipolytic action. This action was determined by adding to 20 c. c. of sterile butter fat 6 to 8 c. c. of a culture grown five or six days in sterile milk at 30° C., mixing thoroughly by shaking in cold water, and incubating at 23° C. The acid number was determined from time to time, using a separate flask for each determination, and making, at the same time, gelatin plates to ascertain the purity of the culture. The rate of increase of free acid under these conditions was found to be as follows:

TABLE IX.—Increase of acid number by action of T.

Age in days.	Acid number.
0	0.6
13	3.5
27	4.4
42	9.3

Check flasks, made by adding sterile milk to fat, showed no increase in acidity. In this set action of the living cells is not separated from enzymic action that may be present, but the ability of this *Torula* to produce a lipolytic enzyme may be demonstrated in a very simple way. A small amount of butter fat was emulsified with melted agar and a loopful transferred to a flamed cover glass. After the agar had solidified it was inoculated by transferring on the point of a platinum needle a very small amount of agar culture, and then the

cover glass sealed with vaseline on a drop-culture slide. In twenty-four hours a small colony had developed about the point of the inoculation. By observing it from day to day with a low magnification, the fat droplets in the vicinity of the colony could be seen gradually disintegrating until, after several days, it was surrounded for some little distance by a clear zone. This is also shown by the effect on butter fat of an old milk culture in which the action of the cells was eliminated by the addition of an antiseptic. A culture was grown in milk one month under favorable temperature conditions, one portion heated ten minutes at 80° C. and formaldehyde added to each part in the proportion of 1:1500. Fat previously heated in a steam bath was added, the mixture sealed in small flasks, and held at 23° C. At the end of seventy-one days, when the acidity was determined, gelatin plates showed that both flasks were sterile. The results follow:

TABLE X.—*Showing presence of enzyme in culture of T.*

Age in days.	Acid number.	
	Not heated; antiseptic.	Heated; antiseptic.
0	0.92	0.92
71	57.56	2.48

There was a slight increase in the acid number of the heated check, caused possibly by the development of acidity in the milk culture before the addition of the antiseptic, or by the splitting of the small amount of fat left by incomplete skimming; or it may have been that the enzyme was not completely destroyed by the ten-minute exposure to 80° C. More recent work, not incorporated in this paper, indicates that the latter is probably the correct explanation. In any case the marked increase in the acid number of the unheated portion could have been brought about only by the elaboration of a lipolytic enzyme by T.

Morphologically, this organism is an elliptical-celled *Torula* yeast, budding at the ends, with little tendency to form chains or clusters. In young cultures the cells are uniform in form and size, usually varying from 3.6 to 4.5μ long by 1.8 to 2μ broad.

Sugars are not fermented. Milk at 30° C. is digested very slowly without previous curdling. In neutral bouillon cultures it is destroyed by an exposure of ten minutes to a temperature of 53° C., or of one minute to 58° C. Colonies do not develop in gelatin containing 1.4 per cent lactic acid nor in gelatin containing 0.2 per cent butyric acid. It grows readily under both aerobic and anaerobic conditions.

The ability to split fat does not appear to be a constant one, but varies with some unknown factor, possibly some slight change in the compo-

sition of the media that would affect the nutrition of the cell. This yeast may multiply in butter for some time without producing any appreciable change in the acidity. Mixtures of butter fat with milk cultures may or may not increase in acidity, and inoculation experiments with sterile cream butter do not always give positive results.

In making inoculated butter the cream was heated sufficiently to destroy the yeasts, but not enough to secure sterilization. For this purpose 4 liters of cream were heated in a large flask ten minutes at 60° C., and, after cooling, inoculated with a pure culture of a lactic acid bacterium. The cream was divided, and to one-half was added a milk culture of T. On the following day it was churned in the flasks, the buttermilk drained off as thoroughly as possible, and the butter washed with boiled water. It was then melted at 40° C., thoroughly mixed, and transferred to small Erlenmyer flasks. It was necessary to melt the butter in order to lessen the chances of contamination in transferring, and to pack it in the flasks without air spaces. It was thoroughly mixed in the small flasks by shaking in cold water. The flasks were held at 23° C., and a separate flask used for each examination.

TABLE XI.—*Yeasts and acidity of experimental butter.*

Age in days.	Inoculated.		Check.	
	Yeasts per gram.	Acid number.	Yeasts per gram.	Acid number.
1 c. c. cream.	302,500	-----	00	-----
2	4,447,000	0.46	00	0.46
7	2,337,000	0.46	00	0.44
13	2,383,000	0.33	00	0.36
32	1,839,000	0.43	00	0.41

The check butter remained free from all organisms that were able to grow on an acid medium and showed no change of acidity. In the inoculated butter the *Torula* multiplied and maintained a high number for some time, but without causing any appreciable change in the acid number.

A second lot of butter made under very similar conditions gave quite different results.^a About 3½ liters of fresh cream were heated for 15 minutes at 60° C., divided into equal portions, and to each was added 200 c. c. of a pure culture lactic-acid bacillus grown twenty-four hours in sterile milk. There was also added to one portion 200 c. c. of a culture of T that was grown forty-eight hours in sterile milk. On the following day the two lots were churned by shaking in flasks, and washed and drained with as little exposure as possible. Salt was added in the proportion of 1:48. Both portions were melted in a

^a Fresh cream for this purpose was supplied by the Dairy Department of the Maryland Agricultural Experiment Station, and the courtesy is hereby acknowledged.

water bath held at 40° to 45° C., and transferred to small flasks, which were sealed with paraffin. The butter was thoroughly mixed by shaking in cold water and was held at 23° C.

TABLE XII.—*Yeasts and acidity of experimental butter.*

Age in days.	Inoculated.		Check.	
	Yeasts per gram.	Acid number.	Yeasts per gram.	Acid number.
Initial.	321,000	0.29	00	0.20
39	Very few.	10.43	00	0.74
42	10,300	9.98	00	0.69
58	28,500	14.13	00	0.78

There was in this case a marked increase in the acidity of the inoculated butter. The *Torula T* was found to be present in each of the four inoculated flasks, while the check flasks were entirely free from yeasts. The acidity of the check butter increased slightly from the low initial number, but remained stationary at about the normal acid number of fresh butter.

This particular organism which we have found capable of increasing the acid number of butter may be considered as a type of a class that may, under certain conditions, grow in canned or packed butter and, by the secretion of a fat-splitting enzyme, bring about undesirable changes. The yeasts and the related species of the *Torula*, *Oidium*, and *Monilia* type are widely distributed and need only certain favorable conditions for rapid multiplication.

The butter of series 66 probably gives us an example of a decomposition due entirely to the action of organisms of this class. This butter was made from cream heated to 82° to 85° C. in a continuous pasteurizer at skimming stations. This temperature would exclude the possibility of a milk enzyme, and the enzyme which was evidently present must have been produced after the pasteurization by some of the fat-splitting yeasts or molds.

The anaerobic forms, such as the *Torula* under consideration, would find especially favorable conditions in the highly acid starters commonly used in creameries. The yeasts as a class are favored by an acid medium, and would not, like the great majority of bacteria, be checked by the formation of lactic acid by the sugar-fermenting bacteria. They are even more resistant to lactic acid than the lactic acid bacteria, and would thrive in milk after the latter had been destroyed by the results of their own metabolism. On the other hand, we have seen that this *Torula* is apparently quite sensitive to some of the fatty acids, such as butyric, and its growth in butter would doubtless soon be checked by the presence of free acids of this class. In view of their weak fat-splitting ability and their presence in canned butter in

comparatively small numbers, this class of organisms can hardly be considered as the only cause of the uniform increase in acidity which has been found to occur in canned butter.

(2) *Enzymes from the milk.*—Mafan and Gilett¹³ have demonstrated the presence of a lipolytic enzyme in cow's milk. Spolverini¹⁴ confirmed the results obtained by Mafan and Gilett, and showed that the fat-splitting activity of cow's milk is much weaker than that of human milk and of certain animals.

To test the action of this enzyme on butter fat, fresh milk was obtained from a healthy cow at the Experiment Station of this Bureau. Part of this was heated twenty minutes at 95° to 99° C., and formaldehyde added to each portion in the proportion of 1:1,250. An equal volume of butter fat, which had been previously heated thirty minutes at 95° to 99° C., was mixed with the milk by shaking in cold water and both flasks incubated at 30° C. Gelatin plates made at the end of thirteen and nineteen days showed both flasks to be nearly sterile. The results of the acidity determinations are given in the table following:

TABLE XIII.—Increase of acidity by milk enzyme.

Age in days.	Acid number.	
	Heated.	Unheated.
Initial.	0.47	0.47
13	0.45	0.96
19	0.41	1.35

The acid number of the heated check portion remained unchanged, while that of the unheated milk increased distinctly, indicating the activity of an enzyme secreted with the milk.

An enzyme would doubtless be carried over into the butter, and, although present in small amounts, would be able to bring about the slow decomposition already noted as occurring in canned butter.

In order to determine the direct effect of this enzyme on butter a small lot of butter was made in the laboratory under conditions that excluded the possible action of organisms. About 3 liters of cream, separated from morning's milk, were carried at once to the laboratory,^a divided into equal parts, and the enzyme in one-half destroyed by holding at 60° C. for fifteen minutes. Each portion was cooled to 12° to 13° C. and churned in a large flask, washed in distilled water and thoroughly drained. They were then melted in a water bath held at 45° C. and salted in the proportion of 1:24. Formaldehyde was added to each portion so that the butter would contain approximately 1 part formaldehyde in 1,500 parts of water. This butter was all held in

^aThere was necessarily an interval of several hours between milking and the time of use in laboratory. The possibility of the elaboration of an enzyme by micro-organisms was reduced to a minimum by holding the cream at a low temperature.

small sealed flasks at 23° C. The acid number of each portion was determined at the time the butter was made, at the end of forty-eight days, and again at the end of ninety-two days.

TABLE XIV.—*Showing increase in acidity in butter caused by enzyme of milk.*

Age in days.	Acid number.	
	Heated.	Unheated.
0	0.44	0.58
48	0.33	1.76
92	0.48	3.07

The increase in acidity of the unheated portion was small but still sufficient to show a distinct lipolytic action which would in time bring about all the acidity found in ordinary canned butter.

In the experimental butter given in Table XI the milk enzyme was evidently destroyed by the exposure of ten minutes to 60° C. The optimum temperature for lipase is given by Green¹⁴ as 55° C., but this is evidently too high for the lipolytic enzyme of milk. The thermal death point of this enzyme was determined by immersing a small flask containing 15 c. c. of milk in a water bath and holding it at a definite temperature ten minutes. At the end of this time it was cooled at once, formaldehyde added in the proportion of 1:1,200, and the milk mixed with 30 c. c. of butter fat. These flasks were held at 23° C. and the acid number determined at the end of thirty-one days. The results were as follows:

TABLE XV.—*Thermal death point of milk enzyme indicated by acid numbers.*

Age in days.	Unheated.	45° C.	50° C.	55° C.	60° C.	65° C.
Initial.	0.43	0.43	0.43	0.43	0.43	0.43
31	1.17	0.86	0.90	0.75	0.40	0.40

An exposure of ten minutes to 45° C. materially weakened the enzyme, and at 60° C. it was entirely destroyed. It is probable that more careful work along these lines will show distinct differences between lipolytic enzymes from different sources.

In arranging this paper only those results are included which show clearly the points under consideration. In addition to these, there has been obtained a considerable volume of results confirming those incorporated in this paper.

APPLICATION OF THESE RESULTS.

In preparing butter that is to be held for any extended period of time, especially if it is intended for consumption in a warm climate, it is not sufficient that it be merely hermetically sealed. This will

prevent the development of the aerobic forms causing the rapid increase of acidity, but will not exclude certain anaerobic yeasts which may, under certain circumstances, produce a slow development of acidity, nor the action of the fat-splitting enzyme carried into the butter from the milk.

In order to remove these two factors, the milk or cream should be pasteurized at a temperature high enough to destroy the enzyme, and the starter should be prepared and maintained in such a way that the danger of contamination by yeasts will be minimized. The life of unpasteurized butter will be much prolonged by holding it at a low temperature, thus retarding the action of the enzymes.

It is well known among butter dealers that packed butter, when removed from cold storage and held at a higher temperature, commonly develops an undesirable flavor, usually described as "fishy." This is frequently ascribed to the sudden change from a low to a high temperature, but it is much more satisfactorily explained by the activity of the fat-splitting enzymes. This phase of the question will be taken up and will be the subject of a future report.

SUMMARY.

The early investigations were conflicting, but pointed to the importance of light, moisture, heat, oxygen of the air, and microorganisms as factors in causing the undesirable changes in butter.

Recent work by Jensen shows that light, heat, and moisture are unimportant factors, and that air is to be considered only as the source of oxygen for certain aerobic organisms, which are the real cause of the decomposition of butter fat. This explains the changes in ordinary butter, but not those of butter packed in large tubs or in sealed cans.

The examination of old canned butter shows a marked change in the texture and flavor accompanied by a comparatively small increase in the acid number, that is, in the amount of free acid liberated by the breaking up of glycerides. (Table I.)

Only a few microorganisms were found, nearly all belonging to the resistant spore-forming group of bacteria.

The causal relation of physical agents, as heat and moisture, to this change is excluded by the fact that sterile butter held for one hundred days at 23° C. showed no increase in acidity.

Two lots of canned butter, received when about seven days old, were held at room temperature and examined from time to time in regard to their condition, acidity, and bacterial content. The condition changed slowly, showing when about twenty-five days old a distinct "off" flavor, which increased in intensity, until, at two hundred and ninety-seven days in one case and two hundred and fifty-one in

the other, there was a disagreeable "fishy" flavor and a strong penetrating odor. There was a correspondingly slow increase in the acid number. (Tables III and V.)

The flora in each case was made up almost entirely of bacteria of the lactic-acid forming class with a comparatively small number of *Torula* yeasts and a few liquefying bacteria. Both the lactic group and the yeasts decreased rapidly, until at the end of about one hundred days there were present only a few spore-forming bacteria, mostly of the liquefying group. (Tables IV and VI.)

Since the change in the acidity and flavor went on steadily after the bacteria had practically disappeared, it could not have been brought about by the direct action of the living cells.

This leaves as the most probable cause the action of fat-splitting enzymes.

The presence of an enzyme was shown by the increase of acidity in butter in which the action of organisms was suppressed by an antiseptic, while the heated check portion remained unchanged. (Table VIII.)

An enzyme could be introduced into butter through its elaboration by organisms in the butter itself, or in the milk from which the butter was made, or by its secretion with the milk in the udder.

The predominating species of yeasts in the butter examined was a *Torula* forming a fat-splitting enzyme. This strongly increased the acidity of butter made under experimental conditions, and probably represents a type of anaerobic organisms that may under certain conditions elaborate sufficient enzyme to produce a slow change. (Table XII.)

The presence of a fat-splitting enzyme in cow's milk has been reported. Its influence on the acidity of butter is shown by the increase in the acid number of an experimental butter which was made from fresh unheated cream, and in which the action of organisms was suppressed by the addition of formaldehyde. A check portion, made under identical conditions, except that the enzyme was destroyed by heat, remained unchanged. (Table XIV.)

It appears from this record of investigation that the only rational conclusion is that the changes which ordinarily occur, or which first occur, in canned butter, destroying its fine, fresh flavor and producing other flavors more or less disagreeable, are due to the liberation of free acid, caused mainly, if not wholly, by the action of an enzyme, which, produced in the milk or secreted with the milk in the udder of the cow, is carried over into the butter; or are, in some cases at least, produced in the butter itself through the activity of certain micro-organisms. It seems reasonable to presume that the same agents, the enzymes of the milk acting alone or in conjunction with the yeasts and their resulting enzymes, are responsible for the so-called "fishy" flavor in butter packed in large but unsealed vessels.

BIBLIOGRAPHY.

- (1) RITSEBT.
Untersuchungen über das Ranzigwerden der Fette. Inaug. Diss., Bern, 1890.
- (2) SCHMIDT.
Ueber die Vorgänge beim Ranzigwerden und den Einfluss des Rahmpasteurisirens auf die Haltbarkeit der Butter. Zeit. f. Hyg., Bd. 28 (1898), p. 163.
- (3) VON KLECKI.
Untersuchungen über das Ranzigwerden und die Säure-Zahl der Butter. Inaug. Diss., Leipzig, 1894.
- (4) BROWNE.
The Chemistry of Butter Fat. Jour. Am. Chem. Soc., Vol. 21, 1899, p. 975.
- (5) LAXA.
Ueber die Spaltung des Butterfettes durch Mikroorganismen. Arch. f. Hyg., Bd. 41, Heft 2 (1901), p. 119.
- (6) SCHREIBER.
Fettzersezung durch Mikroorganismen. Arch. f. Hyg., Bd. 41, Heft 4 (1902), p. 328.
- (7) KOENIG, SPIECHERMANN, and BREMER.
Beiträge zur Zersetzung der Futter- und Nahrungsmittel durch Kleinwesen: I. Die Fettverzehrenden Kleinwesen. Ztschr. f. Untersuch. d. Nahrungs u. Genuss Mittel, Berl., Bd. 4 (1901), p. 721.
- (8) JENSEN.
Studien über das Ranzigwerden der Butter. Cent. f. Bakt., 2nd Abt., Bd. 8, 1902, Nos. 1-13.
- (9) KASTLE and LOEVENHART.
Concerning Lipase, the Fat-splitting Enzyme, and the Reversibility of its Action. Am. Chem. Jour., Vol. 24, 1900, p. 508.
- (10) BROWNE.
The Chemistry of Butter Fat. Jour. Am. Chem. Soc. Vol. 21 (1899), p. 975.
- (11) BERTHELOT.
Sur les altérations qu'éprouvent les corps gras neutres au contact de l'atmosphère. Jour. de Pharm. et de Chem., 3rd series, Vol. 27, 1855, p. 99.
- (12) JØRGENSEN.
Microorganisms and Fermentation. Macmillan & Co., 1900, p. 237.
- (13) MAFAN and GILETT.
[The writer has been unable to find the original of this reference. A brief abstract is given in Spolverini's paper.]
- (14) SPOLVERINI.
Sur les ferments solubles du lait. Arch. de Méd. des enfants, Vol. 4, 1901, p. 705.

(Continued from second page of cover.)

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF ANIMAL INDUSTRY—Bulletin No. 58.

D. E. SALMON, D. V. M., Chief of Bureau.

THE FAT TESTING OF CREAM

BY THE

BABCOCK METHOD.

BY

ED. H. WEBSTER,

Inspector and Dairy Expert, Dairy Division, Bureau of Animal Industry.



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., February 4, 1904.

SIR: I have the honor to transmit herewith the manuscript of an article on "The fat testing of cream by the Babcock method," prepared by Ed. H. Webster, inspector and dairy expert, under the direction of Henry E. Alvord, Chief of the Dairy Division of this Bureau.

It is evident from investigations conducted in the field in connection with the gathering of data for this volume that much misapprehension exists in regard to the proper way of making the Babcock test with cream, and that loose and inaccurate methods of doing the work are universally in vogue. This matter becomes of much importance when large operations are involved, consequently the information and directions submitted in the following pages are of value to creamery men and others interested in the subject. I therefore recommend the publication of the work as Bulletin No. 58 of the series of this Bureau.

Respectfully,

D. E. SALMON,
Chief of Bureau.

Hon. JAMES WILSON, *Secretary.*

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THE FAT TESTING OF CREAM BY THE BABCOCK METHOD.

By ED. H. WEBSTER,
Special Agent and Dairy Expert.

INTRODUCTION.

Investigations made during the summer of 1903 among the large centralizing creamery plants in Iowa, Missouri, Kansas, Nebraska, and Colorado revealed some surprising facts in regard to the general practice of handling the Babcock method in cream testing. It would seem that a subject which has had so much attention given it from experiment stations and practical creamery men everywhere would have been thoroughly familiar to everyone in the creamery business. The investigations showed quite the contrary. Men who used the test daily were found to be at fault in many particulars, and in some instances not the first idea of the principle underlying the method seemed to be in the mind of the operator. Much of this has grown out of carelessness on the part of the user and much is due to improper instruction given for the use of the test as applied to cream. These difficulties and the discrepancies resulting therefrom led to a more thorough examination of the whole subject of cream testing by the method named, and it is the purpose of this bulletin to give the result of these investigations. It will be necessary to go over the entire field and follow each step in detail to insure any completeness in the discussion of this subject. Therefore some things may be repeated which may not seem necessary, but there will be enough new, at any rate to most users of the test, to make the subject as a whole interesting.

It may be stated that a large part of the creamery men are gradually departing from the rules for operating the Babcock test as prescribed by standard works on the subject. There are various reasons for this, but uppermost is the shortage which these creameries are experiencing in the overrun or churn yield. In many cases the test is read lower than the instructions would warrant, and in others the methods of sampling and measuring the cream into the test bottle are modified in one way or another. In practically all cases this is not done with

any thought of "robbing the patron," as the phrase is commonly put, but it is done with a conviction that present methods are somewhere at fault, and the attempt is made to even things up and still give everybody his due.

Instances were found where the creamery, as operated under the hand-separator system, was getting considerably less butter from 100 pounds of butter fat from cream than they had formerly obtained from the same measure under the whole-milk system. This seemed to indicate plainly that the method of testing was at fault, for it was justly argued that 100 pounds of butter fat should make the same amount of butter, whether bought as cream or as whole milk.

With this brief introduction to an old but exceedingly important question, the manipulation of the test will be described in detail, faults will be noted, and better methods suggested. Illustrations as to what the results of some practices are in dollars and cents are included in order to emphasize the importance of very careful work by the man who is doing the testing.

The three vital points in making a test are: (1) A true sample of the cream to be tested; (2) an exact quantity of the sample in the test bottle; (3) reading the test accurately. These three statements seem simple enough at first glance, but they are more complex in actual practice, as many a creamery man has been brought to believe when the month's business was checked up.

A TRUE SAMPLE OF THE CREAM TO BE TESTED.

CUSTOM OF DELIVERING CREAM AT STATIONS.

It is the custom of the patrons of the Western creameries to bring their cream to the factory or to the cream-receiving station in any sort of vessel, from a 1-gallon molasses pail to a 10-gallon milk can. The molasses pail may be filled completely full, and the milk can may have but 8 to 10 pounds in it. In the one case the pail is so full that the cream can not be stirred without spilling, and in the other it is so far down from the top of the can and the cream is spread out so thin over the bottom that it is often difficult to get a proper sample after it is stirred. These cases are not ideal, but they are given as they are found in the field, and it is in the field that the testing is done.

The territory in which these investigations were made has two extremes of weather—hot, sultry, summer days, when the thermometer hovers around 100° F. in the shade and 125° or 130° F. on the creamery or receiving-station platform; and the cold, blizzardy days of winter, when the station or creamery is the coldest place in the country except the back of the buggy in which the patron's can has been tied for its ride to the station. These two extremes of weather present their problems to the man who is going to sample the cream, and they are quite different in character.

The cream is received in all kinds of places; it may be in an ideal creamery or receiving station; it may be in the back end of a store of some sort, without hot water or heat of any kind; or it may be on the route wagon, with the sampling to be done by the route driver. All these methods are in accordance with the facts and have to be considered.

THOROUGH UNIFORMITY OF THE CREAM.

When the can of cream arrives at the weigh platform, there are some things of importance to be noted. If the patron has used water to flush or wash out the last of the cream after separating, in most cases this water would be in a layer on the bottom of the can. It is possible that thorough stirring at the farm would overcome this difficulty, but usually this stirring is not done, and the water is in the bottom of the can. The portion richest in butter fat is on top, and there is a gradation which varies with every inch of depth from this richest cream down to the water. The cream may be thick because of the great amount of butter fat in it, it may be thick because it is sour, or it may be thick from age. The first and most important thing in getting a true sample in any of these cases is to make the cream to be sampled uniform throughout in richness and in physical condition. If this is not done, the first step has gone wrong, and every succeeding step will be wrong just to that extent. The final result will be wrong, and in nearly every case the creamery is the loser and the patron the gainer.

This uniformity of the cream can best be obtained in either of two ways—pouring or stirring. It can never be properly done by shaking. Pouring from one can to another is the best way to do it. At most receiving platforms there is nothing at hand but the ordinary 5, 8, or 10 gallon milk cans. These cans have a narrow neck and cause a waste of time and of cream. They waste time because the cream has to be poured slowly, and yet there is always a tendency to hurry, so that a little cream is often spilled. Two or more cans should be provided for this purpose. They should have straight sides and a top entirely open, a good heavy bail, and a large hand-hold near the bottom for grasping to tip and empty them. If the cream is to be poured directly into cans for shipping, the pouring can should have one side elongated like the “nose” of a pitcher or coffeepot. A can of this sort should hold either 6 or 12 gallons, so as to give plenty of space to empty a 5, an 8, or a 10 gallon can of cream without overflowing.

If the patron's cans are not filled too full, the uniformity of the cream may be insured by using a stirring rod in the patron's can. Stir vigorously for a few moments. This rod should be made of good heavy wire with a disk of tin from $3\frac{1}{2}$ to 4 inches in diameter securely soldered to the lower end. This disk should have a slight cup shape and the rod soldered to the inside center of the cup. A good hand-

hold should be bent on the other end of the wire. Make the rod long enough to work to the bottom of a 10-gallon can. Stirring is not so good as pouring, however, and the safest way is to pour the cream and then use the stirring rod a moment in addition.

These methods will answer the purpose in every case except three: (1) The cream may be so thick it will not pour, (2) it may be frozen, or (3) it may be churned. Warm the thick cream until it will pour. If no heat is available for this work, the creamery operator will have to make a guess at the richness of the cream, or test it and probably overestimate the amount of butter fat it contains. When the cream freezes, it is the water which crystallizes out, leaving the richer part of the cream in the center of the can. If a test is made of this central portion the result may be from 1 to 20 per cent too high. It must be thoroughly thawed out and mixed. When the cream is churned, if such cream is received at all, test the buttermilk and estimate the butter.

METHODS OF SAMPLING.

After insuring a uniform mixture of the cream, there are two general methods in use for taking the sample—the dipper and the sampling tube. If thorough work has been done in the first step, a small portion dipped from the cream will be a fair representative of it. A dipper about the size of a No. 10 shotgun shell is the most common in use. If the sample is to be tested at once, enough cream should be taken to make two tests. This insures enough cream for a second test should any accident occur to the first. If a composite sample is kept, a smaller amount should be taken.

If the sampling tube is employed, it should be lowered slowly through the cream, with the top end open, so that it may fill just as fast as it is lowered. When it reaches the bottom, place the thumb tightly over the top of the tube and lift it out. The rich cream from the top of the can will adhere to the outside of the tube. Instances have been noted where the operator rubbed this, or a portion of it, into the sample jar. The effect, of course, is to give too high a test. The tube, in order to work best, should be hot when it is put into the cream. This will help the cream to flow readily into it and will also prevent its sticking to the outside, and the general results will be better. Keep the tube under a small steam jet, and just before using blow it out with steam. This will prevent any cream from the previous test from influencing the one about to be made and will insure the tube being used hot. In the absence of steam pour hot water through the tube. The tube sampler, if properly handled, is the preferable way to secure the sample. It takes a proportional part and is the surest to give a just result when the cream is not thoroughly mixed.

SOME WRONG METHODS.

The amount of cream used in making up composite samples for a large number of patrons runs pretty well up in value when it is computed. If a half-pint sample is taken for each of 1,000 patrons, this is equal to 500 pounds of cream. Each sample will take a little less than 20 c. c. if a full 18-gram charge is used. For 1,000 patrons this will require 20 pounds of cream, leaving 480 pounds to be thrown away because of the corrosive sublimate or other preservative added to it. If the average test be 35 per cent, the amount of butter fat lost will be 168 pounds, which at 20 cents per pound amounts to \$33.60 per thousand patrons. Should this occur twice a month, the loss per thousand for a month will be \$67.20. If there are 10,000 patrons, as is the case with some creameries in the West, this loss amounts to \$672 per month, which is well worth looking after.

Observations in the field were to the effect that in many instances samples were dipped from the top of the can without stirring or pouring; this doubtless checked up with an unpleasant loss for these stations at the end of the month. One instance was observed where the tube sampler was used without stirring or pouring the cream previous to its use; the result would be the same as where the sample was dipped from the top of the can. The tube always lets a little run back into the can before the weight of the cream is balanced by the vacuum created at its upper end; the small amount which thus runs back is nearly all water or very thin cream. This water is weighed as cream and the patron given credit for it; the sample thus taken is, therefore, not a true one and the analysis shows too high a percentage of fat.

If a tester, by careless methods of sampling, makes his average test one-half of 1 per cent too high, the result will be astonishing. This amounts to 5 pounds of butter fat per 1,000, and at a creamery making 5,000 pounds of butter per day the loss would be 25 pounds, or \$5 per day, figured at 20 cents per pound; in a creamery making 20,000 pounds per day it amounts to \$20 per day. Combine this with the loss previously mentioned and it means a total loss of over \$900 per month, if there be 5,000 patrons and a make of 20,000 pounds of butter per day. These losses have actually occurred in many instances at the above ratio per thousand patrons.

AN EXACT QUANTITY OF THE SAMPLE IN TEST BOTTLE.

There are two general methods of procedure in practice after securing the correct sample, namely, by testing each delivery as it is made, or by making a composite sample, which is tested each week or semi-monthly, or in some cases only once a month.

TESTING AFTER EACH DELIVERY.

This is for many reasons a better method than taking a composite sample. The cream is in better condition to test. There is no chance for loss by evaporation, and an absolute check can be kept upon the work each day. The chief objections to it are the extra time and greater amount of acid required for doing the work. (Details of measuring the sample are taken up after the discussion of the composite sample, as they apply to both alike.)

THE COMPOSITE SAMPLE.

There are several things leading up to the measuring of the sample into the test bottle which will be considered first, as they have a direct bearing on the final result.

The sample jar.—When a composite sample is kept, the sample jar is of great importance. It must have a perfectly tight cover to prevent evaporation. The amount of evaporation that may take place is shown by the following data taken from the testing room of a large Western creamery:

TABLE I.—*Effects of evaporation under varying conditions of jar covers.*

Condition of jar cover.	Quantity of cream or milk.	Per cent of fat on—		
		Nov. 13.	Nov. 27.	Dec. 4.
<i>Series A.</i>	<i>c. c.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Tight cover	35.2	37.2	39.4	40.2
Do	70.4	38.2	38.2	39.0
Do	140.8	38.4	38.8	39.2
Loose cover	35.2	39.4	58.6	(a)
Do	70.4	38.4	40.2	42.4
Do	140.8	38.2	39.6	40.2
No cover	35.2	38.4	(a)	(a)
Do	70.4	37.8	51.6	82.8
Do	140.8	38.6	45.4	50.4
<i>Series B.</i>				
Tight cover	35.2	27.8	28.8	29.6
Do	70.4	28.2	27.8	29.2
Do	140.8	27.8	28.0	27.0
Loose cover	35.2	28.2	31.0	34.0
Do	70.4	27.8	35.4	41.6
Do	140.8	27.4	28.4	33.3
No cover	35.2	28.2	(a)	(a)
Do	70.4	27.8	43.6	80.8
Do	140.8	28.0	30.8	45.3
<i>Series C.</i>				
Tight cover	35.2	3.8	3.8	3.8
Do	70.4	4.0	3.9	3.8
Do	140.8	3.8	3.8	3.8
Loose cover	35.2	3.8	4.4	4.8
Do	70.4	3.8	4.0	4.2
Do	140.8	3.8	4.2	4.2
No cover	35.2	4.0	(a)	(a)
Do	70.4	3.8	4.4	5.4
Do	140.8	4.0	4.0	4.5

The jars used in the above test were the ordinary half-pint sample jars used for composite samples. The covers were the "Lightning" pattern. The jars classed as "tight cover" were in good repair and the covers as tight as such jars usually are. The "loose-cover" jars had covers that did not fit well and were left somewhat loose. The "no-cover" jars were entirely open. Each jar contained the number of cubic centimeters of cream recorded under the heading "Quantity of cream or milk." On November 13 the cream was tested and put into the bottles. This test is recorded under the date named. On November 27 and December 4 the samples were again tested, and the records of these tests appear under these dates.

These data are worthy of considerable study. The covers that were supposed to be tight evidently were loose enough to let out some moisture. The smaller samples show the greatest loss. Those marked "Sample dried" were so dried out that they could not be tested at all. The sample jars can not be too carefully looked after, and yet it is no uncommon thing to see jars containing samples without covers or with very imperfect ones.

The result of such practices is inevitable. The creamery will lose money and will, in all probability, never know how it occurred.

Preserving the sample.—The average sample in which a preservative tablet has been placed shows the weakness of the methods of preserving that are commonly in vogue. A bright-red spot appears where the tablet lay in the bottle, the rest of the cream being in no way affected by the tablet. Such a method is a waste of tablets, and the cream sample is practically in the same shape it would have been had no attempt been made to preserve it. The cream is usually thick, or quickly thickens in the jar, and the tablet, although dissolved in it, is not mixed throughout the cream. As quickly as the operator has time after putting the first cream in a jar, if it is too thick, he should warm the bottle to about 100° F., thus bringing the cream to a fluid condition and enabling an easy mixture of the preservative and cream. Usually the next addition of cream can be quite readily mixed with the first. The mixing should be done immediately after adding the sample to the jar. All the jars should be looked over at the end of the day, and any that have not mixed properly should be warmed and shaken up until the mixing is complete.

In the summer time composite samples will sometimes show a separation into layers, the lower portion being whey and the upper part fat and casein. Such samples do not look well, but so far as observations go this does not to any appreciable extent influence the test, provided they are thoroughly mixed before the sample is taken. In the winter season it has not been shown that a preservative other than the cold weather is needed. In shaking composite samples to mix preservative and cream always give a rotary motion to the hand, as this causes the cream to flow around the bottle. A violent agitation will often churn the contents, thus destroying to a great extent the usefulness of the sample.

MEASURING OR WEIGHING THE SAMPLES.

The same precaution used in procuring the sample in the first place must be used in getting it ready for measuring into the test bottle. Bring the cream to a uniform condition by warming the samples to 100° F. or a little more, then pour from one cup to another a sufficient number of times to insure a uniform texture of the cream. Be sure that no cream sticks to the side of the sample jar. There will be no dried cream if the jar has been tightly covered. If dried cream is present the test will not be correct, because some moisture has evaporated. If the cream is lumpy, pour it through a fine sieve and press the lumps through with the finger, as described in Bulletin No. 100 of the Vermont Experiment Station. After pouring the cream until it is uniform, measure quickly the desired quantity before any movement of fat begins toward the top. If the sample has in any way become churned, heat it warm enough to melt the butter fat and very quickly mix and measure out the desired amount. The test of such churned cream can only be taken as an approximation of the true result.

There is only one correct way of securing a true sample, and that is to weigh the cream into the test bottle with a delicate pair of scales or balances. Anyone desiring correct results should not use the pipette measure for cream. There are too many conditions entering into the problem to make the pipette measure at all reliable. The cream, in pouring to get a uniform sample, will incorporate more or less air. Very often it is partially sour when received and in this condition contains many gas bubbles. The specific gravity varies with its richness. Thick and viscous cream may contain large air bubbles in its body which do not move readily to the surface.

Tables for correcting the error due to specific gravity have been compiled and are correct for that factor, but they do not and can not take into account the other factors, which are often of greater importance than the specific gravity. The quantity of cream weighed into the test bottle does not matter, so long as the correct reading of the result can be obtained. Usually 9 or 18 grams are taken, but sometimes a less amount is used.

The details of making the test after weighing out the samples are of so common knowledge as to make it needless to discuss them here. It is sufficient to say that the desired end is a perfectly clear fat column, so that the readings can easily and readily be made.

READING THE TEST ACCURATELY.

This seems the simplest step of all, and yet it has been proven the hardest. Mention has been made of the fact that creamery men were reading the cream test lower than standard instructions warranted. They doubtless reasoned that the test must be too high or they would get an overrun equal to that obtained under the whole-milk system.

Only one creamery in all the territory under investigation had made any attempt to discover why the test seemed to be too high. This creamery, through its chemist, whose work along this line is made use of in this bulletin, had worked out the table below showing that errors of a glaring character were being made in their methods of reading the test. There are a number of different types of cream bottles on the market, and the tests made were between different types of bottles in use at the creamery in question. Those used were the 30 per cent 9-inch, 50 per cent 9-inch, and 50 per cent 6-inch bottles. The first is not in general use, but the last two are used quite extensively in Western creamery practice.

A COMPARISON OF VARIOUS BABCOCK TESTS WITH THE TEST BY
ETHER EXTRACTION.^a

The tests by the Babcock method were made as follows: All bottles were tested for accuracy of graduation before using. Three types were used: First, a bottle 9 inches in length, graduated to read two-tenths of 1 per cent and up to 30 per cent; this type of bottle will be referred to as the 30 per cent 9-inch bottle. Second, a bottle 9 inches in length, graduated to read five-tenths of 1 per cent and up to 50 per cent; this type of bottle will be referred to as the 50 per cent 9-inch bottle. Third, a bottle 6 inches in length, graduated to read five-tenths of 1 per cent and up to 50 per cent; this type of bottle will be referred to as the 50 per cent 6-inch bottle. All samples were weighed on a Torsion balance, sensitive to 10 milligrams. The weights used were tested for accuracy. All readings were taken at 130° F., this temperature being obtained by placing the bottles in water and heating to this point. Three readings were taken from each test, the method being as follows: Reading A, from *a* to *d*; reading B, from *b* to *d*; reading C, from *c* to *d*. The crescent-shaped surface of the fat in the neck of the bottle, as shown at *a b c*, is called the meniscus.

The determination by the extraction method was made as follows: Samples of about 5½ grams were weighed out into fat-free extraction thimbles, charged with ignited asbestos, then dried to constant weight at 100° C. The samples were then placed in a continuous ether extractor and the extraction carried on with ether that had recently been distilled over sodium. After six to eight hours' extraction the flasks containing the extracts were removed and replaced by other flasks and the extraction again continued for three hours. This extraction gave only a trace of fat. The extracted fat was dried to

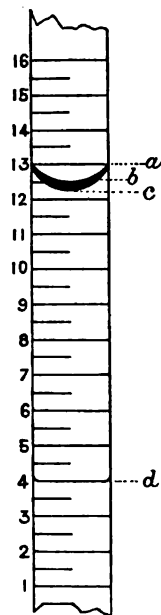


FIG. 1.—The "Meniscus." Section of a test bottle showing readings of fat column from different points of the meniscus.

^a Tests made by C. E. Gray.

constant weight at a temperature of 100° C. Duplicate analyses were made of all samples. Only the averages are given in the table below:

TABLE II.—*Readings of Babcock tests compared with similar figures obtained by ether extraction.*

Sample.	Result by ether extraction.	Results by Babcock method.			
		Reading.	30 per cent 9-inch bottle, 9-gram sample.	50 per cent 9-inch bottle, 18-gram sample.	50 per cent 8-inch bottle, 18-gram sample.
	Per cent.		Per cent.	Per cent.	Per cent.
No. 1	52.32	A	52.90	53.20	53.85
		B	52.50	52.80	53.10
		C	52.00	52.35	52.40
No. 2	43.41	A	44.20	44.10	44.45
		B	43.80	43.70	43.80
		C	43.40	43.30	43.25
No. 3	39.28	A	39.80	39.75	40.00
		B	39.40	39.25	39.40
		C	39.00	38.75	38.75
No. 4	26.23	A	27.00	26.80	27.15
		B	26.60	26.30	26.60
		C	26.20	26.00	26.05
No. 5	23.42	A	23.90	23.90	24.20
		B	23.50	23.45	23.80
		C	23.10	22.95	23.40
No. 6	8.27	A	8.80	8.80	9.55
		B	8.40	8.45	8.90
		C	8.00	8.05	8.25
No. 7	8.30	A	9.00	9.00	9.05
		B	8.60	8.65	8.65
		C	8.20	8.25	8.25

TABLE III.—*Summary of average differences between extraction and Babcock methods.*

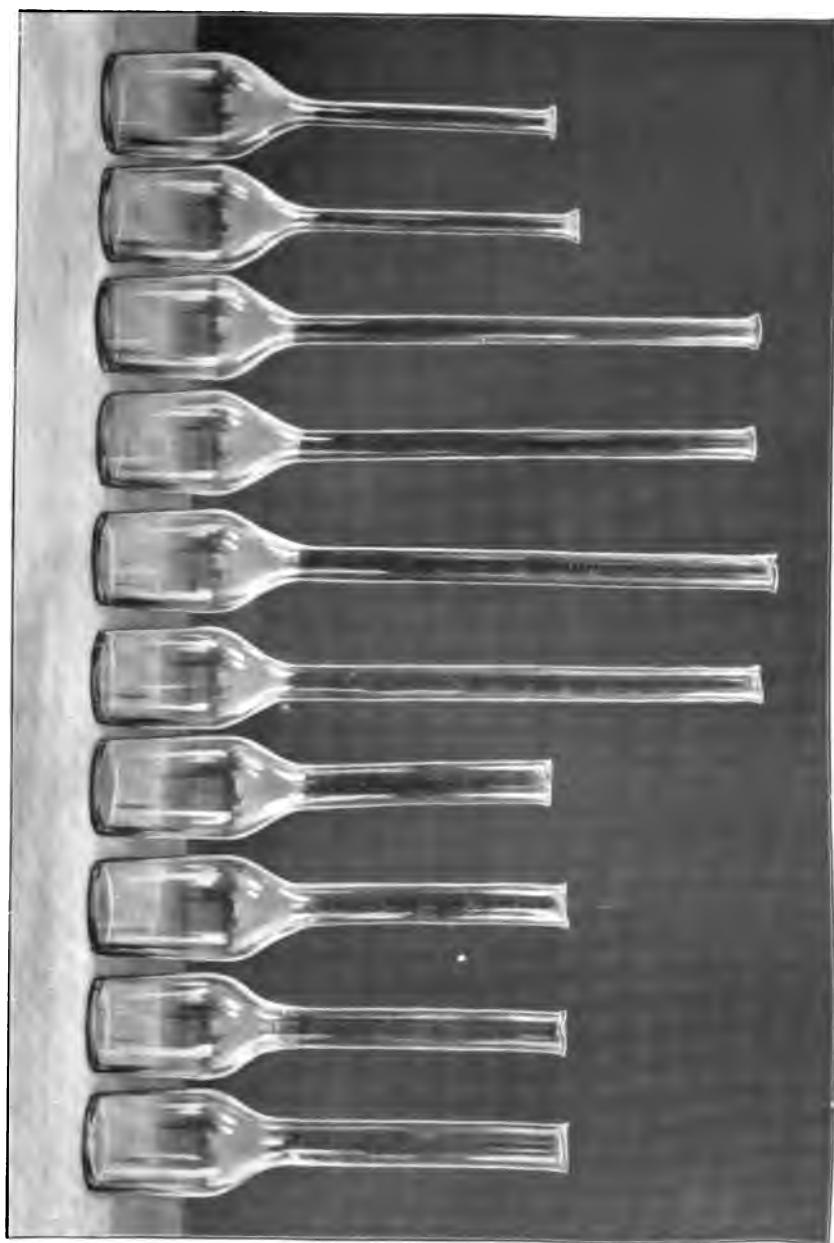
[(+) denotes readings above and (−) readings below those obtained by extraction method.]

Babcock readings.	30 per cent 9-inch.	50 per cent 9-inch.	50 per cent 6-inch.
	Per cent.	Per cent.	Per cent.
A	+0.62	+0.62	+1.00
B	+ .22	+ .19	+ .43
C	− .19	− .21	− .12

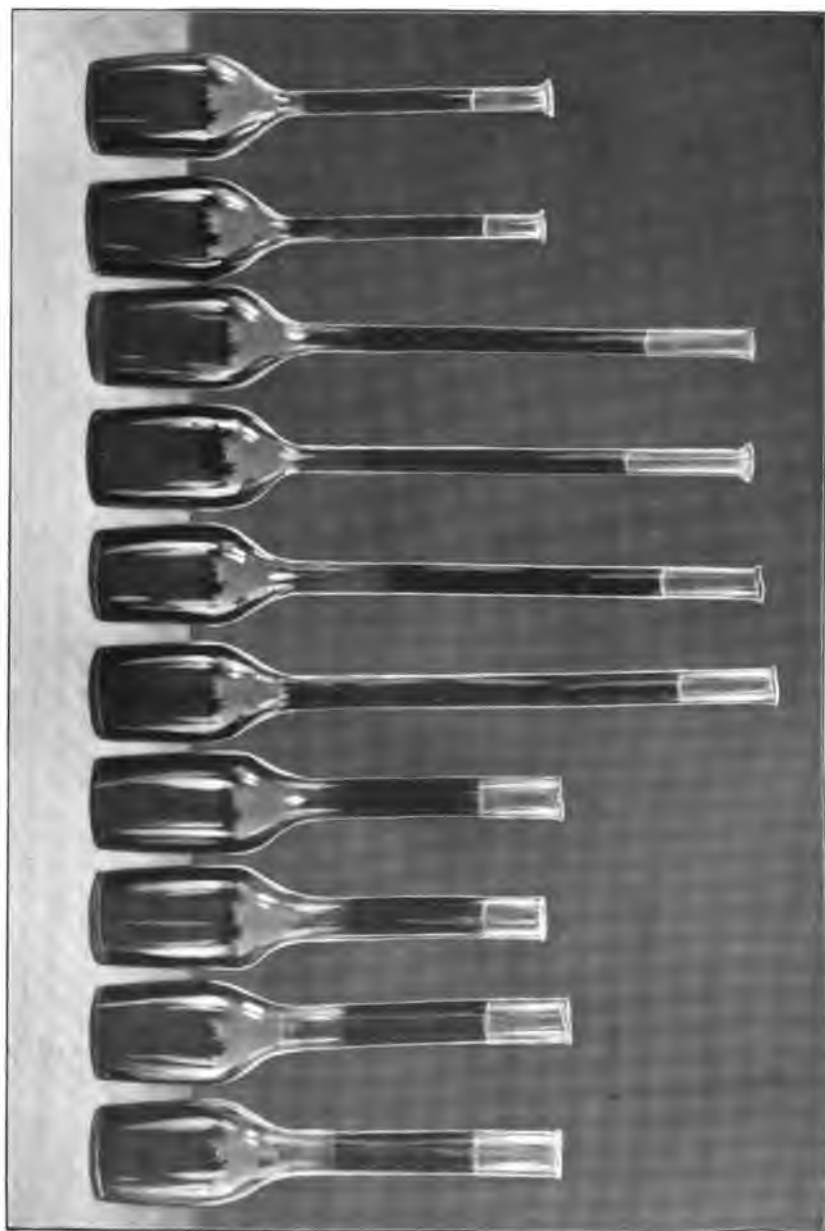
The differences in readings of 9-gram samples were doubled in order that they should appear in such form as to compare with the other columns of the table, which represent 18-gram samples.

A COMPARISON OF MILK AND CREAM READINGS.

The lowness of the milk test as compared with cream readings is exemplified by the following table, which gives the summary of differences as compared with the test made in the 10 per cent milk bottle.



TYPES OF CREAM AND MILK TEST BOTTLES USED IN EXPERIMENTS.



TYPES OF CREAM AND MILK TEST BOTTLES, SHOWING FAT COLUMNS, MENISCUSES, ETC.

The readings were made and the differences found in the same manner as in the comparison with the ether extraction figures, shown in Table III.

TABLE IV.—*Excess of average cream readings A, B, and C over milk reading A.*

Cream reading.	30 per cent 9-inch.	50 per cent 9-inch.	50 per cent 6-inch.
A	+0.51	+0.65	+1.50
B	+ .27	+ .32	+ .75
C	+ .07	+ .05	+ .20

Credit is due to Mr. Gray for suggesting this line of investigation. A careful study of the foregoing tables will indicate that something wrong is pretty sure to occur when the Babcock test is applied to cream by a careless or inexperienced operator. The readings were made at *a*, *b*, and *c* in the above work because these points were quite distinct and could be read without much chance of error. The results show that the probable cause of the differences in the readings of the different types of bottles lies in the meniscus. (See fig. 1, p. 15.) Following out this suggestion, a series of experiments were undertaken at the Kansas Experiment Station.

EXPERIMENTS AT THE KANSAS EXPERIMENT STATION.

Through the courtesy of Prof. J. T. Willard, director and chemist of the Kansas station, Manhattan, Kans., the author secured the use of the station chemical laboratory and the cooperation of the assistant chemist, Mr. R. H. Shaw, in carrying on further the work already outlined. Prof. J. O. Hamilton, assistant professor of physics in the Kansas State Agricultural College, gave material assistance in the mathematical and physical problems involved. Experiments were repeated with the same results as obtained in the work already quoted and shown in Tables II, III, and IV.

ERRORS CAUSED BY INCORRECT READING OF THE MENISCUS.

The most interesting feature of the work was a study of the effect of the meniscus in bottles of different diameters on the reading of the test. A series of thirteen bottles were selected ranging in diameter of neck from 0.2338 inch to 0.5862 inch. The bottles were filled with water to some point in the lower part of the neck, and then 1 gram of pure butter fat weighed into the neck. The specific gravity of the fat was 0.9, and each gram should represent just 5.55 plus per cent butter fat. The bottles were whirled in a hand tester and read at 120° F. Readings from extreme top to bottom of fat column were carefully made and the depth of meniscus measured and recorded in per cent of the scale on which the reading was made. The following

table gives the style of bottle, diameter of neck, the per cent of fat, the depth of meniscus in same terms as fat, and the difference from the true amount:

TABLE V.—*Effect of meniscus in bottles of different diameter.*

Style of bottle.	No. of bottle.	Diameter of neck.	Per cent of fat.	Per cent meniscus.	Difference over true amount (5.55 +).
10 per cent milk	13	0.2338	5.70	0.20	0.15
	12	.2682	5.80	.80	.25
	3	.2858	5.90	.40	.35
30 per cent 9-inch cream	42	.3066	5.90	.50	.35
	5	.3204	6.00	.50	.45
	7	.3356	6.10	.60	.55
50 per cent 9-inch cream	34	.3916	6.25	.80	.70
	32	.4100	6.25	.90	.70
	45	.5016	6.75	1.50	1.20
40 per cent 6-inch cream	44	.5232	7.00	1.80	1.45
	25	.5498	7.00	2.00	1.45
	20	.5684	7.25	2.25	1.70
50 per cent 6-inch cream	19	.5862	7.40	2.25	1.85

It will be seen in the above table that the 10 per cent milk bottles give a reading of 5.70 and 5.80, respectively, and that the 50 per cent 6-inch cream bottles give a reading of 7.00, 7.25, and 7.40, and that the meniscus of the 10 per cent bottles is 0.20 and 0.30, while for the 50 per cent 6-inch bottles it is 2.00, 2.25, and 2.25, and, further, that the 10 per cent bottles read 0.15 and 0.25 above the true amount and the 50 per cent 6-inch bottles read 1.45, 1.70, and 1.85 above the true amount. This is especially interesting from the fact that all of these bottles have been supposed to read alike. It will also be seen that the 10 per cent bottles read more than the true amount, whereas in general practice the reading of these bottles is supposed to indicate the amount exactly. In ordinary milk testing it is estimated that about two-tenths of 1 per cent adheres to the inside of the bottle below the neck, and in reading the per cent of fat the total length of the fat column will just give the desired reading. In the above table the fat was weighed into the neck of the bottle and was therefore known to be all in the neck, and the effect of the meniscus is thus as apparent in the 10 per cent bottles as with the others.

If we calculate that about the same amount of fat is held back in the bulb of all bottles, regardless of size of the neck, it will be seen that the differences—as shown in the last column of the above table—regularly increase as the necks of the bottles increase in diameter. Taking No. 13, the first bottle in the table, as a standard, the differences from the true amount, here taken as 5.70, are seen to range from 0.10 in bottle No. 12 to 1.70 in bottle No. 19.

This shows the actual errors that would constantly be made in regularly testing with these bottles.

Table V shows that the depth of meniscus increases with the diameter of the neck, and that the true reading comes somewhere between the reading of the top and the reading at the bottom of the meniscus. A careful inspection of Table V will show that if from the depth of the meniscus there is deducted four-fifths of itself, the result will be very near the true difference in reading between that which the bottle actually gives and the true amount. Therefore the shortest rule that can be given to correct the error due to the meniscus is as follows: Read the test from the extreme top to bottom of fat column; deduct from this reading four-fifths of the depth of the meniscus, and add 0.2 per cent to the result. The 0.2 per cent is the amount supposed to adhere to the test bottle and is not shown in the fat column in the neck. In none of the cases in the table will this rule give exactly the right figure, but the differences are all, with one exception, less than one-tenth of 1 per cent.

TABLE VI.—*Showing corrected readings after deducting portion of meniscus, as per rule.*

Style of bottle.	Number of bottle.	Read- ing.	Depth of men- iscus.	Four- fifths of meniscus.	Reading less four- fifths of meniscus.	Reading less four- fifths of meniscus + 0.2 per cent.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
10 per cent milk	13	5.7	0.20	0.16	5.54	5.74
	12	5.8	.30	.24	5.56	5.76
	8	5.9	.40	.32	5.58	5.78
30 per cent 9-inch cream	42	5.9	.50	.40	5.50	5.70
	5	6.0	.50	.40	5.60	5.80
	7	6.1	.60	.48	5.62	5.82
50 per cent 9-inch cream	34	6.25	.80	.64	5.61	5.81
	32	6.25	.90	.72	5.53	5.73
40 per cent 6-inch cream	45	6.75	1.50	1.20	5.55	5.75
	44	7.00	1.80	1.44	5.56	5.76
	25	7.00	2.00	1.60	5.40	5.60
50 per cent 6-inch cream	20	7.25	2.25	1.80	5.45	5.65
	19	7.40	2.25	1.80	5.60	5.80
Average		6.40	1.07	.86	5.54	5.74

If the 10 per cent bottles are taken as correct and as standards in this case, the final average is only 0.01 per cent less than the average reading of the 10 per cent bottles, the latter being 5.75 per cent.

If a 9-gram sample is used and the result must be doubled, the 0.2 per cent must not be added until the four-fifths meniscus is deducted and this result multiplied by 2.

The differences shown in Table VI occur because it is a practical impossibility to read the exact amount in any test. In the 10 per cent bottles and the 30 per cent 9-inch bottles tenths have to be estimated; in the 50 per cent 9-inch bottles anything less than 0.5

per cent has to be estimated; in the 40 per cent 6-inch bottles used in this test anything less than 1 per cent has to be estimated; and in the 50 per cent 6-inch bottles used anything less than 0.5 per cent has to be estimated. All of this estimation makes not only possible but altogether probable errors in reading which range from less than 0.1 per cent to as much as 0.5 per cent. The space occupied by 1 per cent in the large-diameter bottles is so shallow that a slight tipping of the bottle away from the perpendicular may easily make a difference of from 0.25 per cent to 1 per cent in the reading.

Applying the rule for reading the meniscus to the readings in Table II, the following is the result:

TABLE VII.—Results of applying rule for reading meniscus to readings found in Table II.

Number of sample.	Style of bottle.	Reading. ^a	Meniscus.	Four-fifths of meniscus.	Reading less four-fifths of meniscus.	Double reading.	+0.2 per cent.	True reading (by extraction).
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	30 per cent 9-inch	26.45	0.45	0.36	26.09	52.18	52.36	52.32
	50 per cent 9-inch	53.20	.85	.68	52.50	-----	52.70	
	50 per cent 6-inch	53.85	1.45	1.16	52.69	-----	52.89	
2	30 per cent 9-inch	22.10	.50	.40	21.70	43.40	43.60	43.41
	50 per cent 9-inch	44.10	.80	.64	43.46	-----	43.66	
	50 per cent 6-inch	44.45	1.20	.96	43.49	-----	43.69	
3	30 per cent 9-inch	19.90	.40	.32	19.58	39.16	39.36	39.28
	50 per cent 9-inch	39.75	1.00	.80	38.95	-----	39.15	
	50 per cent 6-inch	40.00	1.25	1.00	39.00	-----	39.20	
4	30 per cent 9-inch	13.50	.40	.32	13.18	26.36	26.56	26.23
	50 per cent 9-inch	26.80	.80	.64	26.16	-----	26.36	
	50 per cent 6-inch	27.15	1.10	.88	26.27	-----	26.47	
5	30 per cent 9-inch	11.95	.40	.32	11.63	23.26	23.46	23.42
	50 per cent 9-inch	23.90	.80	.64	23.26	-----	23.46	
	50 per cent 6-inch	24.20	.95	.76	23.44	-----	23.64	
6	30 per cent 9-inch	4.40	.40	.32	4.08	8.16	8.36	8.27
	50 per cent 9-inch	8.80	.75	.60	8.20	-----	8.40	
	50 per cent 6-inch	9.55	1.30	1.04	8.51	-----	8.71	
7	30 per cent 9-inch	4.50	.40	.32	4.18	8.36	8.56	8.30
	50 per cent 9-inch	9.00	.65	.52	8.48	-----	8.68	
	50 per cent 6-inch	9.05	.80	.64	8.41	-----	8.61	

^aThis column gives the highest reading (A) in each case.

In the above table the column headed "Reading" is the extreme reading, and the column headed "Meniscus" is the difference between "a" and "c," as shown in fig. 1 (on p. 15). For the 30 per cent 9-inch bottles only one-half the amounts given in Table II are used, as one-half is equal to the 9-gram reading that was taken in this case. This is corrected to the proper amount in the column headed "Double reading." The column "+0.2 per cent" gives the corrected reading, and the column "True reading" gives the amount determined by the extraction method.

A rearrangement of the final results in the above table makes the following showing. The sum of the seven samples is taken and the average differences determined:

TABLE VIII.—*Showing average excess of Babcock readings over extraction readings.*

Style of bottle.	Average reading less four-fifths of meniscus.	0.2 per cent addition.	Corrected reading.	Average true amount.	Average difference.
	<i>Per cent</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
30 per cent 9-inch.....	28.69	0.20	28.89	28.74	+0.15
50 per cent 9-inch.....	28.71	.20	28.91	28.74	+ .17
50 per cent 6-inch.....	28.83	.20	29.03	28.74	+ .29

The column "Average reading less four-fifths of meniscus" is the average of double the 30 per cent 9-inch readings, and the 50 per cent 9-inch and 50 per cent 6-inch readings. To these is added the 0.2 per cent for the corrected reading. From the corrected reading is taken the average true amount, which gives the difference found in column "Average differences." This is the average above the true amount for each reading "A" in the three classes of bottles represented in Table II. It is doubtful in making these readings in Table II whether the meniscuses were read deep enough, as they were not read with a thought of this comparison in view.

Another possibility enters into the proposition that will have to be left an open question for the time being; that is, whether 0.2 per cent is not too much to allow for the fat which does not rise into the neck when testing cream in the wide-necked bottles. In Table VI it must be remembered that the fat was weighed into the neck of the bottle, and that the amount was positively known to be in the neck. The table was arranged from Table V, with the supposition that 0.2 per cent would remain below the fat column in all the bottles, and that being the case, the assumption that in the 10 per cent bottles the reading would actually be the same as if the test had been made in the regular way and read 5.7 per cent for No. 13, etc. While this is true for the 10 per cent bottles, it may not be true for the cream bottles, as Table VIII would seem to indicate. In view of the fact that nearly every error in sampling and making tests tends toward a larger reading than the correct one, the addition of the 0.2 per cent might safely be omitted and no injustice done to either party of the transaction.

It is a common practice to use a 9-gram charge and double the reading. This multiplies the error made in reading by 2. An examination of the diameter of the bottles given in Table V will show the wide variations to be found in bottles of the same class. The 13 bottles used in this experiment were selected from 50 bottles taken at random from a large stock, and they show almost every grade of variation.

It would not be a safe rule to deduct a certain amount from bottles of the same per cent reading, the differences between bottles of the same class being as great as between classes.

THE LOWER MENISCUS.

Among other things observed in making this test was the lower meniscus or line between the fat and the liquid below. When the bottles were whirled for five minutes in a tester in which the temperature remained constant, the line between the fat and water was a straight line. Immediately on cooling this line began to have a curved shape, the center being lower than the sides. If the bottles were placed in a hot bath and the temperature raised above that at which they had been whirled, the line curved upward, the center becoming higher than the sides. These changes in the shape of the bottom line, or plane of division, were nearly equal in effect to the upper meniscus. If the line curved either way, the effect was to increase the reading. The curve downward, due to cooling, did not affect the reading as much as the curve upward, due to heating. As the fat is drawn down and the bottom reading made lower, the fat column is shortened at the top, and this in a measure equalizes the error. When the center is moved upward as the result of expansion, the top is pushed up and the bottom line remains the same; the line that touches the glass is then the one from which the reading will be taken. This effect has been observed where a hand tester had a steam connection for heating the bottles. The operator would turn in the steam for the last whirling of one minute and then read the test. This sudden heating caused an expansion, and the movement of the fat and liquid on the surface of the glass being slower than that in the center, the bottom line of the fat column was curved upward, and consequently the reading was too high.

ERRORS DUE TO EXPANSION BY HEAT.

In testing cream the matter of expansion of the fat is of considerable importance. An experiment made by Mr. Gray is here recorded which shows the effect of expansion in heating the fats to temperatures ranging from 110° to 140° F.

Plan of test.—A sample of pure butter fat was separated from pure, fresh butter. A determination of the specific gravity of this fat showed it to be normal (0.9004 at 100° C.) compared with water at the same temperature. Samples of the fat were weighed into the various types of test bottles and skim milk enough added to each to make 18 grams. The fat and skim milk were mixed as thoroughly as possible and the test made as with cream. From this mixture a test was obtained that in appearance was very similar to the regular cream test. Three readings were taken from each test [as described in fig. 1 (p. 15)], at temperatures of 140°, 130°, 120°, and 110° F. Six tests were made with each type of bottle, and the results averaged as in the following table. The correct amount is very near 39.8 per cent. (That is, this would be the accurate reading or test for the fat actually present in this mixture or unnatural cream.)

TABLE IX.—Average readings of six bottles at different temperatures, showing expansion.

Style of bottle.	Reading.	Temperatures.			
		140° F.	130° F.	120° F.	110° F.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
30 per cent 9-inch, 9-gram.....	A.....	30.1	30.0	19.9	19.85
	B.....	19.9	19.8	19.75	19.75
	C.....	19.7	19.65	19.65	19.65
30 per cent 9-inch, reading doubled.....	A.....	40.2	40.0	39.8	39.7
	B.....	39.8	39.6	39.5	39.5
	C.....	39.4	39.3	39.3	39.3
50 per cent 9-inch, 18-gram.....	A.....	39.9	39.7	39.5	39.5
	B.....	39.4	39.3	39.2	39.1
	C.....	38.9	38.9	38.8	38.7
50 per cent 6-inch, 18-gram.....	A.....	40.5	40.3	40.1	39.9
	B.....	39.9	39.8	39.6	39.5
	C.....	39.0	38.9	38.7	38.6

TABLE X.—Average changes in readings at stated temperatures due to heat expansion.

Style of bottle.	Temperatures.			
	140° to 130° F.	130° to 120° F.	120° to 110° F.	140° to 110° F.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
30 per cent 9-inch, 9-gram.....	0.1	0.1	0.05	0.25
Same, doubled.....	.2	.2	.1	.5
50 per cent 9-inch, 18-gram.....	.2	.2	.0	.4
50 per cent 6-inch, 18-gram.....	.2	.2	.2	.6
Average full reading.....	.2	.2	.1	.5
Theoretical difference.....	.142	.142	.142	.427
Same, 9-gram.....	.071	.071	.071	.213

The average increase in reading when the temperature is raised from 110° to 140° is 0.5 per cent, as taken from the readings in Table IX. The theoretical increase is 0.427 per cent. The difference between the practical reading and the theoretical calculation is but 0.073 per cent, which is less than can be read in either of the styles of bottles in the test. The coefficient of expansion of fat is given as 0.00064 for melted butter fat within the range of temperatures as found in common testers in use. For each change of 10° F. 1 c. c. of fat, or 5 per cent, will change 0.0178 per cent. In the above illustration there was 39.8 per cent, or nearly 8 c. c. of fat, and the change would be eight times 0.0178 per cent, or 0.142 per cent, as shown in Table X. Fifty per cent cream would be ten times 0.0178 per cent, or 0.178 per cent. Thirty per cent cream would be six times this factor, etc.

The correct temperature for reading is given as 120° F., and in Table IX the readings, taken at 120° and corrected by the rule for

calculating the correct reading, give results nearest to the true amount, 39.8 per cent.

It will be seen that the differences of reading, when 9 grams of cream are used, are just one-half of those from a full charge, or 18 grams, so far as temperature is concerned. It will also be seen that when the readings of the 9-gram charge are multiplied by 2 to obtain the correct reading, the difference is also multiplied by 2, and the final result is the same as though 18 grams had been used. There has been an objection raised against the long-necked cream bottle to the effect that so long a column of fat necessarily shows more expansion and greater care must be exercised to have the temperatures just right. A careful consideration of the expansion table above will not bear out this assertion. Butter fat expands volumetrically. Cream-test bottles are graduated volumetrically and will take care of any expansion, no matter what the shape of the neck. With the long scale and the narrow neck the expansion is measured in just the same proportion as in a short scale and wide neck.

The hand tester will, as a rule, give nearer the right results than the steam-turbine tester, because the fat from the hand tester is usually read nearer 120°. The steam machine may heat the bottles to 160° or 180° F., and if read at this temperature a little calculation will show the nature of the results. If the steam machine is run with the lid raised an inch or two, better results will be obtained. This will allow an air current to be drawn through the machine, and the temperature will thus be kept down. If bottles are placed in a water bath to bring them to the right temperature for reading, they should remain in the bath for twelve to fifteen minutes before being read to insure an even temperature of fat and liquid below the fat and to insure a straight line between the two.

FINANCIAL RESULTS OF INCORRECT READING OF TESTS.

It has been stated before that a difference in test of one-half of 1 per cent would amount to \$1 for every 1,000 pounds of butter made if valued at 20 cents per pound. In the preceding discussion it is shown that in the matter of reading the test alone a difference of 1.7 per cent can be made. Figured on the same basis as the above, this would equal \$3.40 per 1,000 pounds, or \$68 per day on an output of 20,000 pounds.

The methods of operating and the basis of paying for butter fat in the centralizing plants give the farmer all there is in it. In other words, the farmer in most cases gets a price for a pound of fat or the cream containing it which, together with the transportation charges on this cream, will equal the selling price of a pound of butter. The creamery must make its profits and pay its running expenses out of the overrun it is able to obtain. If this overrun is cut down through

mismanagement of any kind, profits are gone. Instances are now on record where concerns have become bankrupt through bad management along these very lines. The test question is but one item in the way of successful operation, and the things pointed out in this bulletin are not all the corners that must be watched in getting a proper overrun; but so far as the testing goes, this bulletin points out the dangers which are of vital importance to the creamery manager.

The following are examples of shortages occurring on several systems in Kansas and Nebraska largely due to improper methods of testing:

TABLE XI.—*Showing losses occurring at cream-receiving stations in Kansas and Nebraska, 1902-03.*

Month.	Stations.	Butter fat received at factory.	Butter fat paid for.	Loss.	
				Pounds.	Per cent.
1902.	Number.	Pounds.	Pounds.		
June.....	174	572,936	581,424	8,488	1.45
August.....	179	481,216	483,612	2,396	.49
September.....	178	399,276	396,575	a 2,701	a .67
October.....	175	239,847	244,816	4,969	2.08
November.....	175	191,088	197,672	6,684	3.35
December.....	164	173,602	181,598	7,996	4.35
1903.					
May.....	109	377,576	362,891	15,315	3.89
June.....	177	812,871	817,908	5,032	.61
July.....	181	655,691	657,806	2,115	.32
September.....	192	439,073	439,886	813	.18
Do.....	21	64,326	69,550	5,224	7.49
July.....	259	794,870	812,303	17,633	2.17
August.....	257	761,055	777,486	16,431	2.10

a Gain.

One-half of 1 per cent is allowed for mechanical loss by some of the larger creameries. Out of the 13 cases represented above, there are four within this limit—one showing a gain of 0.67 per cent and one very close to the limit.

The butter fat paid for and the butter fat received are found by testing at the station and at the factory. When this was checked against a low churn yield, this and the difference between the test called for an investigation. Not all of it can be laid to any one thing, but with careless sampling, loss of cream by spilling, etc., reading the test at too high a temperature, and reading the full meniscus, the losses may be found. The differences between the station and the factory tests are in the main due to poor work in sampling and testing at the station. It is a noteworthy fact that the tests at the factory are made more carefully than those at the stations. The station tests as a rule are made by pipette rather than scales. In most cases a cor-

rection table is used to correct the errors made by pipette measure. Although this method gives lower results than with the scales, the faulty methods of sampling, combined with too high reading, still give the station a higher test than shown at the factory, where the samples are usually weighed and more carefully read.

During the past year the creamery companies that have kept any records of their work have been cutting down this difference between tests and helping to correct the low churn results. It is hoped that the ideas given in this bulletin will be of some benefit to them; also to others who have not realized the possible loss along this line and the great probability that they have sustained it, although ignorant of the fact.

SUMMARY.

CONDENSED DIRECTIONS FOR MAKING FAT TESTS OF CREAM.

SAMPLING:

- (1) Uniform composition and texture of cream is necessary.
- (2) This is obtained by pouring from one pail or can to another.
- (3) Frozen cream must be thawed before it can be sampled.
- (4) Churned cream can not be successfully sampled.
- (5) The tube sampler gives surest results.
- (6) The dipper sampler does well if the cream is thoroughly mixed.
- (7) Cream adhering to outside of tube should not get into sample jar.
- (8) The tube should be blown out with steam or rinsed with hot water before using each time.
- (9) Keep the top of the tube open while it goes down, so it may fill as fast as lowered.

KEEPING THE SAMPLES:

- (1) Sample jars must have tight-fitting covers and be kept tight.
- (2) If cream is dried in bottles it is evidence that covers are not tight enough to prevent escape of moisture.
- (3) Preservatives must be thoroughly mixed with cream; if too thick, heat the jars.
- (4) Do not shake the bottle to mix the cream; give it a rotary motion.
- (5) It is best to have samples protected from extreme heat or cold.
- (6) Churned cream gives only approximate results; dried cream gives too high results.
- (7) Extreme hot weather and lack of attention may cause separation of whey.
- (8) Do not take too large samples; it is a waste of cream.
- (9) Look after samples every day and see that they are in proper shape.

PREPARING SAMPLE FOR MEASURING INTO TEST BOTTLE:

- (1) Sample must be absolutely uniform throughout.
- (2) Heat sample to about 100° F., or until it is quite fluid.
- (3) If sample is weighed, a much higher temperature may be used.
- (4) Pour from one cup to another until uniform.
- (5) The hotter the sample the more fluid it will be and the easier to make uniform.
- (6) Take care that no cream remains in sample jar adhering to the sides.
- (7) If sample is lumpy, press lumps through a fine wire sieve (such as is used for a teapot strainer).
- (8) Melt any churned samples, mix, and sample quickly.
- (9) Make things convenient for this work and see that it is thoroughly done.

MEASURING INTO TEST BOTTLE:

- (1) Weighing the sample is the only method that will give correct results.
- (2) Use delicate balances and keep them in perfect order.
- (3) Test weights and scales for accuracy before using.
- (4) Torsion balances are very accurate; weigh one test at a time.
- (5) Less than 9 grams may be used, but 9 or 18 grams are more convenient.
- (6) Air and gas bubbles in cream cause pipette tests to be inaccurate.
- (7) Specific gravity of cream causes pipette tests of cream to be too low.
- (8) Tables for correcting specific gravity are in use, but they do not correct for error caused by air and gas.
- (9) Weighing corrects all difficulties due to specific gravity and air or gas in cream.
- (10) Use great care to get the weights exactly right.

MAKING THE TEST:

- (1) If 18 grams of cream are used, add an equal weight of acid of 1.82 to 1.83 specific gravity.
- (2) If 9 grams of cream are used, add an equal amount of water, then add acid as for 18 grams.
- (3) Use enough acid to make a clear fat column; determine by trial.
- (4) Use condensed steam or rain water for filling bottles.
- (5) After adding acid, fill bottles at once to bottom of neck with water at about 120° F., and then whirl five minutes.
- (6) Then add water of same temperature to bring fat within scale, and whirl two minutes.
- (7) Keep the temperature down to 120° F. while whirling.

MAKING THE TEST—Continued.

- (8) Have a hole drilled in top of tester to insert thermometer.
- (9) Run the tester at as high speed as bottles will stand.
- (10) For hand tester put in boiling water when beginning the test till it nearly reaches the bottles.
- (11) For steam tester raise the lid slightly while making the test.
- (12) When through whirling keep tester closed, so as to maintain heat even as possible.

READING THE TEST:

- (1) See that line between fat and water is straight, and read from bottom to extreme top of fat column.
- (2) Read the depth of meniscus and deduct four-fifths of it from previous reading. A careful operator can estimate this.
- (3) Add 0.2 per cent to the result.
- (4) For 9-gram sample, double reading before adding 0.2 per cent.
- (5) Read at a temperature close to 120° F.
- (6) If bottles are placed in bath to regulate temperature, allow them to stand for fifteen minutes before reading.

THE TEST BOTTLES:

- (1) Use as narrow-necked bottles as possible, to get wide divisions of scale.
- (2) The 30 per cent 9-inch bottles graduated to 0.2 per cent are most accurate.
- (3) Use 9-gram charge with these, doubling the reading.
- (4) The 50 per cent 9-inch bottles are next in accuracy, graduated to 0.5 per cent.
- (5) The 30 per cent, 40 per cent, and 50 per cent 6-inch bottles are too inaccurate in results.
- (6) In wide necks the scale divisions are too close together and errors are more probable.
- (7) All bottles should be tested for correctness of calibration.
- (8) With cheap bottles nearly half are not correct.
- (9) Bottles guaranteed correct can not all be depended upon.

CONCLUDING NOTES.

Little more need be said except that there is still much work to be done to make a perfect cream test, free from the objections noted in this bulletin. The subject of preservatives for composite samples of cream is one that needs the attention of the chemists. A test bottle that will overcome the objectionable features noted is a study for some genius to work upon. A bottle of uniform diameter would greatly simplify matters as they stand, so that a uniform correction could be made for all tests. The great importance of careful work in all details should be urged upon every user of the test. The amount of butter fat that may adhere to the bottle and remain below

the neck should be studied and a large number of experiments made to determine the facts in the case. The common defects observed in field work were improper sampling, poor sample jars, the pipette method used in measuring samples, the test read too high and at too high temperature, and carelessness all along the line.

The question of overrun, while in very close touch with and influenced by the test, is not all dependent upon it. Losses occur due to careless weighing of cream, guessing at the weight of cans, leaving cream in cans while emptying, losses by spilling, and losses in shipping. The greatest factor of all influencing the overrun may be found in the churning and working of the butter. The question under discussion must not be lost sight of, however. Table X is food for reflection along this line. The just distribution of money to patrons and the financial results of the creamery industry in the West call for more careful consideration of this question of the cream test.

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(Continued from second page of cover.)

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF ANIMAL INDUSTRY—BULLETIN NO. 59.

D. E. SALMON, D. V. M., Chief of Bureau.

THE FARM SEPARATOR:

ITS RELATION TO THE CREAMERY
AND TO THE CREAMERY
PATRON.

BY

ED. H. WEBSTER,

*Inspector and Dairy Expert, Dairy Division,
Bureau of Animal Industry.*



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GOVERNMENT PRINTING OFFICE.

1904.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., April 26, 1904.

SIR: I have the honor to transmit herewith a manuscript entitled "The farm separator: Its relation to the creamery and to the creamery patron," prepared by Ed. H. Webster, inspector and dairy expert, under the supervision of Maj. Henry E. Alvord, Chief of the Dairy Division. In submitting this manuscript for my consideration, Major Alvord gives an outline of the work, from which I quote:

"This paper embodies in part the results of Mr. Webster's investigations and experiments during the last calendar year. It will be of general interest, and particularly useful in the districts where dairying has been recently introduced on the farm-separator system.

"In order to assist in the investigation thus reported the Continental Creamery Company of Kansas offered the use of a part of its regular daily shipments of cream to the factory at Topeka, from producing farms nearly 300 miles distant, keeping the transportation under control, and permitting a full examination to be made of the selected cans of cream upon arrival at the factory. The company also contributed the services of its chemist, Mr. C. E. Gray, to assist Mr. Webster in these experiments, and Mr. Gray was temporarily appointed a special agent of the Bureau of Animal Industry.

"The Post-Office Department courteously made a special ruling which permitted the data to accompany the cans of cream in tag envelopes instead of being separately mailed, and thus contributed much to the facilities for conducting the experiments."

I respectfully recommend that the report be published as Bulletin No. 59.

Respectfully,

D. E. SALMON,
Chief of Bureau.

Hon. JAMES WILSON, *Secretary.*

Dy-52.

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THE FARM SEPARATOR: ITS RELATION TO THE CREAMERY AND TO THE CREAMERY PATRON.

By ED. H. WEBSTER,
Special Agent and Dairy Expert.

INTRODUCTION.

This subject is treated in this bulletin wholly from the standpoint of Western practice. The section of the West in which the observations were made lies almost altogether within the boundaries of Kansas and Nebraska. Not formerly in the list of dairy States, these two have had a history in dairying both unique and interesting. The first lessons in the industry were paid for by the farmers, at the rate of about \$100 per lesson, in cooperative stock creamery companies which had been organized by persuasive and persistent promoters. These lessons were well impressed and are remembered even to the present day, although the creamery, with its \$6,000 or \$7,000 investment, has long been used for purposes quite foreign to its original intent. No doubt farther East, where there were more dairymen, investments of this sort made by the farmers turned out better and such ventures were often successful. West of the Missouri River the farmer was not a dairyman and had no intention of becoming one; and although he took a hundred-dollar share in the creamery he was skeptical as to the outcome and did not propose to sell any cream until the venture was a success. He may not have known that this very attitude wrecked all prospects of success. Here and there were exceptions to the usual failures which the first lesson brought. These exceptions only served to prove the rule that where there were no cows, no experience in the business, and no inclination to become dairymen a cooperative or a stock company creamery could not live. The few exceptions were in neighborhoods where the farmers went to milking and stuck to it. These earlier creameries were on the "gathered-cream" system—a system in which every step was ruinous under Western conditions.

Along in the early nineties the skimming station began to make a sweeping change in creamery practice in these Western States. A new impetus was given to the business, and again the farmer was urged to put up his dollars for another lesson. The idea had been conceived of skimming the farmers' milk at a station and shipping the cream to a central point for churning. This lesson usually cost the

farmer about \$25, and the result was much more satisfactory for a time than the first had been. A station was built which the farmer owned and a creamery was leased. The farmer hauled his milk to the station and hauled his skim milk home. The average distance was not less than 6 miles. One thing that helped the industry at this time was a general period of depression, the cow seeming to be the only thing which would yield an assured income. Although prices of butter were comparatively low, the business boomed. Following this, a few prosperous years came and the farmer wearied of the long haul and the small returns he was getting. He hired out the hauling; this ate up the profits. With easy money in other lines of farming and but little profit in the milk business, dairying again had a setback. Skimming stations became expensive to operate because of the small amount of milk handled, and it looked as though many of the small centralizing plants had met their doom. For mutual protection and with a hope of building up the business again, many of these smaller creameries consolidated, forming large companies.

A few enterprising men had by this time taken up the crusade for the farm separator.^a They were frowned upon by all conservative creamery men. Separator agents multiplied, however, and began to pile up evidence that the farmer could cut off the great expense of hauling milk both ways, and farmers began to buy. This was the third lesson they were paying for. The \$100 necessary to buy a separator was a mountain of difficulty at first, but the trained separator agent could figure profits that would finally tempt the most conservative.

It soon became evident that the farmer was going to have a separator. The conservative creamery man now began to see that if the farmer bought a separator and was opposed by his creamery in so doing the cream would go somewhere else. This opened up the whole territory west of the Missouri River and the creameries, large and small, began to push the farm separator for all they were worth. The separating station dropped out of view almost as suddenly as it had appeared, scarcely ten years before. The strenuous time in the farm-separator business was now partially transferred from the field

^aThe machine here referred to is the centrifugal cream separator, or the dairy centrifuge. The invention was brought to this country from Europe about 1879, but was not generally adopted until some years later. The first centrifugal cream separators were hand machines operated by a crank. Then steam power was used, applied by belt and also directly, as in the operation of turbines. Separators have become commonly known through the use of power machines at creameries and separating stations. The farm separator is the same machine—the centrifugal cream separator—of a size and pattern suited to do the work on the farm. Generally it is small and operated by a crank turned by hand. But it may be fitted for use with a dog, bullock, or other animal, or by water, or any power convenient on the farm. Hence while the farm separator is usually regarded as a hand machine, the way in which it is operated is merely a matter of suitability and local economy.—H. E. A.

to the factory. Separator companies could not keep up with their orders. Farmers could hardly wait until a machine could be delivered to them. To be sure, this great demand was not created in a day. The pioneer work for the farm separator was slow and discouraging to those who were carefully fostering its interests. The farmer had already bought a creamery and then a skimming station, and it was almost the "last straw" to ask him to buy a separator. Here and there a machine was sold and the leaven began to work. To-day the creamery business of Kansas and Nebraska is a cream-gathering system, and the farmer has the separator in his home. In the more thickly settled portions a few skimming stations still remain, but their days are numbered.

The day of speculation as to the probable trend of the business is past. The farmer now has a separator and the creamery has the product from it. The question is no longer, Will the creamery man sell machines? but, What can the farmer and the buyer of cream do to make their use more profitable to all concerned? This issue must be met intelligently on both sides. The farmer must learn that he has a big part in the final success of the system and the creamery man must learn that it does not all depend upon the farmer, but that there are things in factory management which he must study and put in practice. So interwoven are the lines leading to success that one side of this question can not be discussed with any completeness without also taking the other side into account. As a matter of convenience, as well as for logical sequence of events, the discussion will begin with the farmer.

I. ADVANTAGES OF THE FARM SEPARATOR TO THE DAIRYMAN.

The reason for the rapid spread of the farm separator among the dairymen of Kansas and Nebraska has already been suggested.

RELATIVE COST OF HAULING MILK AND CREAM.

The average distance of hauling over this territory is about 6 miles. The farmer grew tired of this steady job himself and then of paying the profits to some one else for doing the work, and finally he quit the business. The cost of hauling the milk both ways, in the farmer's time or in the money he paid for hauling, was a greater tax than the industry would stand. This cost was never less than 10 cents per 100 pounds, and it was often 15 cents or more. This meant a direct tax of $2\frac{1}{2}$ to 5 cents per pound on butter fat that was worth but 15 to 20 cents when delivered. No industry could stand this tax and live. It ought not to stand it. This tax on the business furnished one of the leading arguments for separator salesmen, and rightly so, but, like most good things, this argument was abused. The farmer was making the trip every day with his milk to the station. It was held out to him

that with the separator he could go once or twice a week, or whenever he got a canful of cream. This was an easy argument, and it took well. The creamery men saw the danger, but for the time seemed powerless to act. They accepted it as an inevitable result of the introduction of the farm separator and fought against its introduction. But they were powerless to lower the cost of hauling milk and had to accept the change. There is, however, one thing that the farmer will yet have to unlearn, if he has not done so already. He must recognize that cream is a perishable article, and under the most favorable conditions will soon become unfit as a food product.

The change to the home separator proved a means of reducing the cost of hauling, in time or money, to 1 cent or less per pound of butter fat. This difference in cost between the two methods went into the farmer's pocket. The result was an increased interest in the business and greater receipts at the creameries.

COMPARATIVE VALUE OF FARM-SEPARATOR SKIM MILK AND CREAMERY SKIM MILK.

One of the great drawbacks of the old system was the serious loss in the value of the skim milk. The long haul to the station and the long haul home consumed from five to eight hours, and often more. When the cans of skim milk were delivered at the patron's door the milk was usually in bad condition, and the calves that were forced to drink it were in a worse one. The skim milk was one of the things that never failed to bring out a strong argument against the dairy business. Wise ones often filled the dairy papers with articles about how to feed skim milk to calves successfully, but these wise ones didn't live at the end of a 12 mile route, where they had to feed the article as it was delivered to them, after being from eight to ten hours on the road. It was a common story that skim milk killed the calves and pigs and was not worth the hauling home. This was probably much overdrawn, for it was very difficult to buy any of this skim milk at the factories. It was not so good as it should have been, but it was needed and recognized as indispensable by every farmer. The introduction of the farm separator, however, wrought a great change. In visiting hundreds of farmers who are using farm separators, the writer has not heard one word of complaint on the score of the skim milk. Calves, pigs, and chickens are greedy for it and all are doing well on it. Men who would never consider the business under the old system have been convinced that, with a separator at home, they can raise good calves, and have become creamery patrons.

INCREASE IN THE BUTTER FAT.

Many authentic instances are on record where the farmer has sold from one-fourth to one-third more butter fat from the same herd after buying a separator; not that he did not get pay for all butter fat that

he delivered to the creamery when he hauled milk, but because he did not deliver all the butter fat to the creamery. The skim milk was coming back from the creamery in condition unfit for the calves. New milk was fed them instead. This happened often, with the result that the calf was eating butter fat worth from 15 to 20 cents per pound when an equal amount of corn chop worth about 2 cents per pound would have served almost as well. When the farm separator was bought, the calves were weaned earlier from whole milk; in fact many of them got no more whole milk. The butter fat was sold. Then again many who hauled their own milk had to quit for a while in the busy season. They could not spare a team to take the milk in. When they bought a separator the children with the old family horse and cart delivered the cream as regularly in these busy seasons as in any other. Under the old system occasionally a can of milk would sour and be returned, and Sunday's milk could hardly ever be kept over. With the separator this never occurred. Thus many farmers were very much surprised to find their monthly checks from one-fourth to one-third larger than they had been before.

INCREASED NUMBER OF COWS.

When the separator was purchased the farmer found he could just as well milk a few more cows. He had plenty of cans; he did not have to spend a half day delivering the milk; and, besides, the separator had to be paid for. The result has been an increased number of cows in the dairy and a corresponding increase in income per farmer all over the territory under consideration.

INDEPENDENCE OF CREAMERY.

There came to each purchaser of a separator a feeling that he was independent of any one concern. This, while not a matter of advantage perhaps in actual income, was a mental relief that was worth something. The cream could be shipped far or near just as he chose or as the creamery man could interest him. This feature of the farm-separator system has not done as much damage to the creameries as they at first thought it would. The farmers find their home men honest and stand by them.

INCREASED PRICE FOR BUTTER FAT.

The increased price of butter fat was an argument that was used to good effect and with some truth. A few creameries went so far as to pay more for butter fat shipped by the farmer direct than for that which the station was made the medium of gathering. The price paid to farmers is higher in proportion to the butter market than it was under the whole-milk system. This results from competition to get

business and also from the fact that there is less expense, on the whole, attached to the cream system. This increased price may, however, be temporary, as will be pointed out further on.

THE DANGERS THE FARMER IS APT TO ENCOUNTER.

There are apparently no dangers that have been real; but some serious ones may develop unless the farmer studies the situation and follows the instructions given him by his creamery. With the introduction of the farm separator, where everything is so obviously to the advantage of the farmer, he should not forget that the success or failure of the whole enterprise hinges largely on the demand there may be for the product of his separator. If the creameries are forced to turn out a second-grade or third-grade product because of inferior cream, sold by indifferent farmers, the disadvantages to the farmer may become painfully apparent to him. The fact is that, up to the present date of writing, the quality of butter produced from farm-separator cream has been inferior to what it was in the same territory under the whole-milk system. This has caused much loss to creamery men and will ultimately react on the producer of cream, unless he takes some radical steps to better the quality of his product. With this thought in view, the matter of the care of the separator and the cream will be discussed. It is hoped that the farmer will take this matter to heart and seriously consider the question of his future profit in the business and how he can best obtain it.

II. THE FARM SEPARATOR: ITS CARE AND MANAGEMENT.

Separator companies issue books of instruction with each machine which are sufficiently clear and comprehensive. These will insure good care of the machine if followed. It sometimes happens, however, that the purchaser thinks he knows more about the machine and how it should be used than the manufacturer. Such a one generally comes to grief.

THE MECHANICAL OPERATION OF THE MACHINE.

The separator is made for one specific purpose—that of skimming milk. The skimming is done wholly by centrifugal force—that force that makes a ball pull on a string if it is attached to one end and whirled around the hand in a circle. The pull that is exerted through the string, as though the ball were trying to get away, is the centrifugal force. The centrifugal force in a separator causes the milk to flow away from the center of the bowl and hug the inside of the bowl wall. The skim milk thus forces its way to the parts farthest from the center, while the cream, which is lighter, lags behind and collects in the middle of the bowl. Strictly speaking, the skim milk, being heavier, is separated from the cream by the action of centrifugal

force, instead of the cream being extracted from the milk. Openings on the outer edge of the bowl carry off the skim milk and an opening near the center carries off the cream. One is discharged below the other and they are caught in different pans or receptacles and thus carried away from the machine.

The various patterns of separators found on the market have different devices in the bowl for aiding the separation. These are always purely aids. The old style hollow-bowl machines had simply a bowl with a wing soldered to the inside in a line with the axis or central shaft to make the milk revolve with the bowl. There was more or less remixing of cream and milk after it started to separate, and the efficiency was low both as to closeness of skimming and to quantity of work done. Every internal device used in separators has been put there to overcome these difficulties—to keep the milk from remixing, to make it pass through the bowl in a steady flow, and to divide it up in such ways that a greater quantity of milk can be passed through the bowl and receive the action of the separating force. The steady even flow secured by these devices is also obtained or helped by a perfectly steady and uniform motion of the bowl. If the machine shakes while it is skimming there will be some intermixing of the milk and cream and the result is poor skimming. The operator should aim to secure two things if he expects his machine to do good work: (1) A perfectly true motion of bowl, and (2) a sufficient speed (which must be uniform) to create force for separating.

In order to have the perfect motion of the bowl, the machine must be set level and be kept clean and well oiled. The oil should be thin, or light, so that it will not gum the wearing parts. A heavy oil will make the machine run hard and will gum quickly on small high-speed bearings. All the bearings of the machine should be frequently flushed with coal oil. It is well to make a run about once in two or three weeks, using coal oil on all the bearings. This keeps the parts free from gum and washes out grit or sand that may have blown into them. It is an excellent plan to have a cover of close-woven cloth or oilcloth, that can be kept over the machine while it is not in operation. This will keep out dust and sand and will add materially to the lasting powers of the machine. The separator should be set up on a good solid floor, so that it will not move about as the operator turns the crank.

Uniform centrifugal force is obtained by turning the crank at a given speed at all times and giving the crank an equal pressure at all points in its circuit around its axis. All machines have marked upon them, or given in the instruction book, the number of revolutions the crank should make per minute. Follow these instructions, counting the revolutions each time the machine is operated and frequently during operation, to be sure the speed is maintained. This is a point

in which much careless work is done. Too many guess at the speed, and they seldom guess right. It is a good rule never to guess at anything when it is possible to know. The writer has found variation all the way from 25 to 75 revolutions per minute in the operation of machines by guess. At neither of these extremes would the operator believe that he was wrong, until he had been made to count the number of revolutions by the watch.

The life of a separator depends mainly upon the factors just pointed out. A machine that is allowed to run gummy or dirty may wear out in a year. If kept free from dirt and well oiled it will last a number of years. One of the objections urged against the separator has been that it would not be properly handled and that one or two years' service would wear the machine out. After visiting several hundred farms and inspecting as many machines, the writer has concluded that the farmers, as a whole, are taking much better care of their separators, mechanically, than was anticipated. Machines have been noted that had seen several years' service and were still practically as good as new. In a few instances careless operators had nearly worn a machine out in less than twelve months. The farmer never bought a machine before in the use of which he was so frequently and urgently reminded that he must take care of it.

SPEED OF MACHINE.

This has already been discussed, but it should be noted here that the greater the speed the greater the centrifugal force, and thus the greater the efficiency in separation. The speed at which a machine should be run is indicated by the manufacturer. Never run less than this; it is not practicable to run more. Slow speed has two effects on the work of the machine: (1) The separation will not be complete and (2) the cream will be thin. The incomplete separation means a loss of butter fat left in the skim milk. This loss should be avoided, and it can be by running at the required speed. Count the turns of the crank by the watch.

QUANTITY OF MILK FLOWING THROUGH THE BOWL.

In most machines this flow is fixed by the size of the opening and the height of the supply can; in some it is not. Within certain limits the amount which passes through the bowl has a decided effect upon the separation. The faster the milk passes through, the shorter the period in which the centrifugal force acts on it and the less complete is the separation. If the amount of milk is turned off about one-half, by partially closing the faucet over the bowl, the cream will be thicker. It may become so thick that it will not flow from the machine. If the float should be removed and the pan be allowed to run full of milk, without any other change of condition, the cream would be very thin.

In this, as in change of speed, the quality of the skimming is affected. The greater the supply of milk the less perfect the skimming, and if the supply should become so small that the cream would not flow from the machine, all of the milk would pass out through the skim-milk tubes.

TEMPERATURE OF MILK.

The warmer the milk the more fluid it is. It is a rule adopted by all creamery men in operating power machines that the milk must be separated at a temperature above 85° F. Cold milk is more viscous, or less fluid, than warm and the cream will not separate so readily. If this is true of power machines, where everything runs more uniformly than is possible with a hand machine, it is certainly true of the hand machine. It is one of the stock arguments of some separator agents that their machine will skim cold milk. Probably the statement is true. If so, it shows a wide range of adaptability for the machine and that it is so built that it is difficult to clog up. Take the argument for what it is worth, but do not skim cold milk unless you expect to leave some butter fat in the skim milk. The milk should be separated as quickly as possible after milking; then the skimming will be cleanest, the skim milk will be best for the calves, and the cream will keep better.

THE CREAM SCREW.

The function of the cream screw is to regulate the percentage of butter fat in the cream separated, and enable the operator to make allowance for changes of season and character of milk to the extent that a uniform cream may be obtained under all conditions, if so desired.

One of the most frequent questions asked is, "Why does my test vary so much?" The reasons have nearly all been given in the foregoing paragraphs. The test varies with the speed of the machine, with the amount of milk run through the machine, and with the temperature of the milk. Every machine has some device for changing the test of the cream when these factors remain constant. It is done either by an adjustable outlet for cream or skim milk. In most cases the adjustment is in the cream outlet. Directions for adjusting the cream screw are given in the books of instruction that go with the machines. There are some factors of separation not mentioned above which influence the percentage of fat in the cream. These factors are usually overcome by proper adjustment of the cream screw. In the summer, when the cows, on green, succulent pasture, are at their best and giving large quantities of milk, the milk is easy to skim. The reverse is true in winter if the cows are wholly on dry feed. It is usually the case that milk tests higher in butter fat in winter than in summer if most of the cows calved in the spring. These facts have their influence on the test of the cream. As a rule, rich milk will give

the richest cream, other things being equal. It will give no more butter fat than is contained in the milk, but the cream will be richer in butter fat. The proportion of milk to cream remains about the same, therefore the cream tests richer in fat. It thus happens that in winter the cream screw has to be set so it will make a larger quantity of cream from a given amount of milk than is customary or necessary in summer.

THE SANITARY CONDITION OF THE MACHINE.

If the mechanical care of a machine is important as affecting its durability, the sanitary care of the machine is doubly so as affecting the purity of the product which passes through it. Milk—one of the best and purest of human foods—is one of the quickest to become unfit for food if it is not kept clean and handled in clean vessels. While the purchaser of a separator has been again and again impressed with the idea that it must be kept in perfect order, the same agent who went to such pains on this point has told him that the parts which come in contact with the milk need not be washed oftener than once a day and that the cream could be delivered once a week. It would be one of the greatest blessings to the dairyman, the creamery man, and the consumer of butter if the machine should go to pieces in a month if not kept scrupulously clean every minute of the time. It is right here that the advantage of the hand separator to the farmer may turn to naught unless the fact that cleanliness, which is so essential to purity of product and to profit in the business, is thoroughly impressed upon the user. It is not enough to rinse the machine out with a little warm water and let it stand until next time. It is the slime and solid particles of unclean matter in the milk that are caught and held in the bowl. The temperature is just right to set this material to decaying at once; and if the parts are not clean, an evil smell soon develops. The machine must be well washed after every separation of milk.

There are some things that the average housewife needs to learn about washing vessels that come in contact with milk. The dishcloth as found in the average kitchen should never be used on dairy utensils. It is the exception where one will be found to smell sweet an hour after it has been used; and yet milk utensils are often washed with it and wiped with a towel that has done duty on all of the china and glassware of the household, and possibly the pots and kettles, before the tinware of the separator is touched. Discard the dishcloth and the dish towel when the milk utensils are being washed. Wash them in warm water first, with plenty of some washing compound, and use a brush to do the work, but never a rag. Get into every part of them, after which rinse off with clean warm water, and then either put them in boiling water or pour boiling water over them. Stand the parts up so that they will drain, and

use no cloth to wipe them. The hot surface will dry them quickly, and they will be clean. Leave the parts in a sunshiny place if possible. This may seem to be putting too much stress on the case, but evidence gathered in the field shows the need of some vigorous words along this line. The outside of the frame, which does not come in direct contact with the milk, needs the same scrupulous care. Cases have been noted where the color of the machine could scarcely be distinguished because of the grease and dirt or dried milk covering the paint. Pure cream could hardly be expected ever to come from such a place. It is pleasant to know that at more than three-fourths of the farms visited the separators were well kept and the people were trying to do the best they knew how. There was, however, a great lack of knowledge, and this should be supplied to the users of separators in some way or another. It is hoped that this bulletin may do something in that line.

III. MANAGEMENT OF CREAM ON THE FARM.

The dairy industry of Kansas and Nebraska is comparatively new. It is not the main business of the farmer, but rather a side issue, forced upon him by adverse conditions or aggressive creamery agents. The farmers of this section have never given the matter their serious attention. They know that it brings them in a steady income, but it is confining, and they will not milk unless they have to. This is the general condition of the business. With this as the prime incentive, the farmer feels that he does not want to put any expense into the business that is not necessary. This line of thought has practically prevented him from spending any money for better care of his dairy products. He has the cows and the separator, and the market that takes his cream asks but little of him in the way of quality. Naturally, but little has been done to keep the product pure from the time the cow has been milked. Times are changing rapidly in this respect. The creameries are requiring quality tests to be made of the patron's cream and are paying for it on that basis. This is going to bring the farmer face to face with a new proposition. He must learn how to care for his cream in such a way that he may deliver it to the creamery in perfect condition.

CLEANLY MILKING.

This is the starting point of most of the trouble with cream: The milker sits down with a pail, open at the top, and begins to milk. Any dust, straw, or manure that may be hanging to the udder is gradually worked off and finds its way into the milk pail as the milking proceeds.

It is not the province of this bulletin to enter into any lengthy discussion of the subject of bacteriology, but enough must be said to give a clear understanding of the effect of mixing with the milk this dirt from the hair and udder of the cow. Every particle of such dirt carries with it a quota of germ life. This germ life consists of minute plants, so small that they can not be seen without the aid of a microscope. The function of this plant growth is to cause decay. All decay is brought about by the action of this germ life, or bacteria. Germ life requires certain things to promote growth, just the same as does corn, wheat, or any other plant with which the farmer is familiar. The corn requires food, moisture, and warmth to make it grow and thrive. These must be furnished at the right time and in the right form or the corn does not thrive. It is just so with germ life. The germs require proper food, warmth, and moisture to grow. All of the conditions which best promote the growth of these minute, invisible plants are found in warm milk as it is drawn from the udder. Thus while the dairyman milks he unconsciously plants; he plants the seed of destruction in the very product he is going to market. The destruction begins at once and is carried on very rapidly so long as the proper temperatures are maintained.

The remedy would naturally suggest itself. Stop the dirt from getting into the milk. This can be done easily and quickly. If the milker will carry with him a damp cloth and carefully wipe off the udder and the parts immediately around it, the trouble will to a great extent be prevented. All of the coarser particles of dirt will be rubbed off and the finer particles of dust dampened so that they will not fall into the pail. This work will require but a few moments of extra time and would prevent much after-trouble in the way of sour and ill-flavored cream. The cow should be milked in a place in which the air is free from dust. In the winter, or when the cows are kept in the stable, never feed, or move hay, or clean out the place, or do anything to stir up dust or strong smells just before milking.

SEPARATING.

The cream should be separated at once after milking, while the milk still has the animal heat in it. The work of the day should be so arranged that this can be done. Do not use a cloth strainer. The separator will remove all the solid dirt that may be in the milk much better than it can be done with a strainer. There never was a cloth strainer used that would not in a few days become yellow and smell bad. Under the best conditions, where steam can be used to help in cleansing, the cloth strainer is more of a snare than a benefit. A well-made wire strainer might be used, but there is no need of any strainer. Pour the fresh, warm milk directly into the supply can and send it through as quickly as possible.

COOLING THE CREAM.

At once on finishing the skimming begin the cooling of the cream. The calves can wait a few minutes better than can the cream. There are devices made for cooling the cream as fast as it comes from the separator. They are good and can be made of much service if kept clean, but they add to the number of utensils that have to be washed and, like the strainer, they may be dispensed with. The dairyman should provide himself with enough cans, made after the old style "Cooley" or "shotgun" can, to hold the cream. A can of this kind holds from 3 to 5 gallons, is about 20 inches deep and 9 inches in diameter. These cans are the best to keep the cream in at the farm. They are convenient to use and keep clean, and they present a large cooling surface, which is a great advantage in cooling cream.

Immediately after separating set the pail or pails of cream in a tank of cold water and stir, testing the temperature with a thermometer until the cream is as cold as the water. This point is imperative if success is to be obtained. As with the cleaning of the cow, this is a matter of a few extra minutes, but it will be a factor in deciding success or failure. The stirring rod and the thermometer should be considered as indispensable as the crank on the separator, and yet hardly one in five hundred farmers of the West have a thermometer that can be used for this purpose. If the can of cream is set in a tank of water and left without stirring, it will be hours before it becomes thoroughly cool. In the meantime the germs which have gotten into it in spite of the greatest of care have been multiplying at a tremendous rate and the cream goes to the station spoiled. At the temperature of ordinary well water the development of the germs is very slow, and for this reason no time should be lost in cooling the cream to this temperature. The thermometer is absolutely the only means by which one can tell whether the cream is cooled or not. By stirring and testing with the thermometer frequently the task of cooling will be found to be short and one will quit with the satisfaction of knowing that the cream is cool. It ought to be cooled down to 60° F., and if the water is cold enough to carry the cream lower so much the better.

HOLDING THE CREAM.

Generally speaking, there is almost an entire lack of facilities for holding cream on the Western farm. The majority of farms have wind pumps at or near the house. The pump furnishes an excellent location for an ideal milk house. On many farms visited the owner had built around the windmill tower, or at one side of it, a building, usually 6 by 8 feet, in which was placed a tank deep enough to set the milk cans and have water come up to their necks. All of the water

pumped for stock and other purposes of the farm is run through the tank and then out into the stock tank. This room often contains the separator and a work table; in fact, here is done the dairy work of the farm. With an arrangement of this kind and a good thermometer the cream should be kept without difficulty from forty-eight to seventy-two hours in the hottest weather. Such a building costs but little, and the convenience of having a place for the milk, cream, and dairy utensils is in itself enough to justify the expense of building it. As a matter of fact, the farmer who is going to get the best price for his cream will have to provide himself with a place to keep it cool until it can be delivered to the station. Keep it just as cool as is possible, without freezing, up to the time it is delivered.

There are some points besides the immediate cooling and holding at a cool temperature that must be observed in order to insure good cream. The different skimmings of cream should never be mixed until both are of the same temperature. The cream when cooled down keeps fairly well, but if some warm cream should be mixed with it the temperature will be raised. At once the germ life becomes more active and souring takes place very quickly. No vegetables or other produce having strong odors should be kept in the same room with the cream. It takes such odors very readily and retains them tenaciously. In fact, keep the milk room for milk and nothing else, and, above all, have plenty of windows to admit sunshine when wanted, and use plenty of "elbow grease" in keeping it sweet and clean.

DELIVERING THE CREAM.

In many instances all the good work done is entirely spoiled because the cream is not cared for in delivery. The writer has observed many thousand cans in process of delivery, and in nearly 99 per cent of them the work was done in such a manner as to damage the cream. For some reason, probably through lack of better information on the part of the person delivering the cream and also on the part of the man receiving it, the cream was handled as though no damage could come to it after it was taken away from the farm. It mattered not whether the heat of the summer's sun or the cold blast of the winter's storm was on, the can of cream was exposed to it all. Withdraw the lid of a can of cream that has been exposed to the heat for one or more hours and the first whiff is a sour one. The cream will be found to be several degrees warmer than when taken from the water tank at the farm. This warming has the same result as mixing warm cream with cold: The germ life is made active and the souring process goes on with greater rapidity than before. It is a simple thing to cover the cream can with a wet sack or blanket and throw over this a dry one, which will effectually stop the mischief. With this precaution the cream will arrive at the station as cool as when taken from the

farm. Why this should be so commonly neglected is almost beyond comprehension, but it is the most universal of all wrong things done by the farmer in the production of pure cream. The same precaution, except that the blanket should be dry, is a sure protection against freezing in winter. Creamery men should insist that cream be delivered properly, to avoid the loss which occurs constantly through carelessness of this kind.

FREQUENCY OF DELIVERY.

It is a safe proposition to say that in 95 cases out of 100 the cream is not delivered oftener than three times per week in summer and twice a week in winter. There are many reasons for this. The objections given to hauling milk apply to cream and are met by less frequent delivery. The distance of hauling is not less than 6 miles on the average, and it is a question whether the patron can afford to make the trip more than three times per week. Some of the larger creameries receive cream but three times per week and others four times, while a number keep their stations open every day except Sundays. From 80 to 90 per cent of patrons of stations that are open every day do not deliver oftener than three or four times per week. The direct shippers, or those who take their cream to the railroad station and ship directly to a central plant, make from one to five shipments per week. The larger number of this class will not average over two shipments per week. They hold their cream until they get either a 5, 8, or 10 gallon can filled. There is a tendency in some quarters to urge farmers to more frequent delivery and in others to insist on better care of the cream between deliveries. The creameries which operate their stations but three times per week are forced to the latter alternative.

The question of delivery should not be placed upon a par with keeping cream at the farm; or, in other words, there is a difference that should be noted on the part of both the creamery and the patron which is of importance to each. The cost of keeping milk and cream at the farm is practically paid when the equipment is put in to properly handle it. This equipment need not be renewed for years if it is properly cared for. The time required to put the cream in shape for keeping, over that spent by the dairyman who neglects this part, is very small. On the other hand, the hauling takes time for every delivery and the cost is always that much more for each delivery made. The investment is never completed, but has to be worked out as time goes on. It is plain that the more frequent the delivery of cream the greater becomes this part of the expense. If it can be shown that cream can be kept forty-eight, sixty, or even seventy-two hours, and delivered in good shape every second or third day without any expense other than a few minutes of attention each day and one original investment, the farmer would not be justified in making six trips per

week where three would do the work, thus doubling the cost of delivery. It is worth the farmer's time to study this question and secure the proper equipment for handling the cream on the farm. Under the ordinary practice now in vogue, with imperfect facilities at hand, the cream is not delivered sweet in 90 per cent of the cases when it is more than twenty-four hours old. This is not because it can not be done, but, as pointed out in the preceding paragraphs, because proper care is not taken before the time of delivery. Let the instructions of the preceding paragraphs be followed, and then the cream can be delivered three times per week in sweet condition.^a

IV. RESULTS OF INVESTIGATIONS MADE AT COLBY, KANS.

Several weeks were spent at Colby, Kans., studying the question of quality and what could be done to improve it on the part of the farmer and the creamery management. Colby is situated in northwest Kansas, and is in a very good dairy community. By this is meant that the farmers are all more or less interested in the business and are milking. The first farm separator in this region was bought not over a year previous to the date of investigation, and the last milk was taken in during the month of the investigation, the station then becoming a cream-receiving point. The equipment, which was similar to that of all western milk-separating stations, consisted of a 12-horsepower upright boiler, an 8-horsepower horizontal engine, a power (belt) separator, and pumps, vats, and testing apparatus. In changing from a milk station to a cream station the separator was stored away and an outfit was put in for pasteurizing the cream. The milk tanks were used for cooling tanks to hold the cream cans until time for shipment. The engine had to be run to pump water and operate the pasteurizer. In common with most western stations, this one was too small to do the work properly. There was not sufficient tank room for keeping the cream cool nor for storing cans. The place was like a great majority of stations in being dirty and ill-kept.

^aThe proposition here made and recommended for carrying cream from the farm to the shipping station only once in two or three days may do for the peculiar conditions existing in the region specially under consideration—the formative stage of dairying recently introduced in a new country. But it will not do to let this stand as permanent advice. For best results there is no doubt that cream should be sent from the farm to the churn with the least possible delay. Daily delivery and shipment of cream should be the aim. How this is to be accomplished, especially where quantities are small and on scattered farms, and is a question which must be worked out by local conditions. It may be done by cooperative effort among farmers, by a carrier paid by them, by a gatherer employed by the creamery, or in some other way. The matter should not be considered as settled right, however, by the owner of the cows or the buyer of the cream until deliveries of cream at the creamery or the shipping station are as frequent and as regular throughout the year as were the former deliveries of milk.—H. E. A.

This description is given in order to show the kind of material often found, and this station was selected for investigation because of its large patronage, its location in the dairy region of the West, and because it was nearly 300 miles from the creamery plant to which the cream was sent and where it was churned.

During the time of the work at this station the farmers were in the midst of one of the greatest wheat harvests ever known in western Kansas or Nebraska; the weather was the hottest of the summer, and altogether the conditions for getting a good quality of cream were as unfavorable as they could be. The first work attempted after cleaning up the station was to ascertain the condition of the farmers' cream when delivered at the station. An acid test was made of every can of cream received for two weeks, and notes on its general quality were taken. It was found that the acid test was the best indication of its general quality. Cream that was delivered sweet was in nearly every case of fine flavor, while that delivered sour was often of very poor flavor. There were occasional exceptions to this rule, but the two ran much more closely together than was anticipated at the start. The following table gives much that is of interest to the dairyman and to the creamery man. The patron's number is given in the first column. The figures appearing under the date numbers are the readings as taken from Mann's acid test, each number representing the number of cubic centimeters of tenth normal alkali necessary to neutralize the acid in 50 cubic centimeters of cream. The arrangement of the table shows the number of deliveries made in two weeks and the number of cans in each delivery. One number indicates that one can was delivered by a patron on that date, two numbers indicate the delivery of two cans by the same patron, and three numbers three cans. This station was open for receiving cream every day except Sunday. This part of the work was begun on Monday, July 20, 1903, and was closed Saturday, August 1.

TABLE I.—Data relating to deliveries of cream and results of tests at Colby, Kans., July 20 to August 1, 1903.

Patron's number.	Results of acidity tests made of cream delivered on—											
	July 20.	July 21.	July 22.	July 23.	July 24.	July 25.	July 27.	July 28.	July 29.	July 30.	July 31.	Aug. 1.
1 a.....	17.5	.....	10.2	.....	9.8	.....	11.7	.....	7.9	.....	18.5	12.2
	34.0	.....	29.4	.....	26.6	.....	.....	.....	25.6	.....	.....	.....
2.....	10.0	3.0	8.8	9.6	10.2	10.2	26.1	9.2	8.8	7.8	.....	14.6
	21.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3.....	23.2	.....	27.7	.....	22.2	26.0	24.5	.....	21.3	.....	22.8	9.2
4.....	21.6	.....	27.0	.....	32.0	16.2	21.8	.....	26.2	.....	20.7	9.7
5.....	26.0	.....	.....	28.0	.....	26.4	25.2	.....	25.6	.....	.....	22.0
6.....	9.2	3.0	9.6	9.6	13.3	9.4	17.0	10.3	8.8	9.1	.....	11.9
	30.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

a When the brace is used it indicates that the patron delivered more than one can at a time on one or more of the dates.

TABLE I.—Data relating to deliveries of cream and results of tests at Colby, Kans., July 20 to August 1, 1903—Continued.

Patron's number.	Results of acidity tests made of cream delivered on—											
	July 20.	July 21.	July 22.	July 23.	July 24.	July 25.	July 27.	July 28.	July 29.	July 30.	July 31.	Aug. 1.
7				22.7								
				22.9		19.2				8.2		
				32.8						23.5		
8	32.4		31.0		22.5	11.8	19.4		13.6		18.7	9.8
9	9.2		17.0		11.2	8.5	12.4		11.4	7.1	6.3	7.8
10	25.0		26.2		27.4	19.0	17.7		21.0		24.0	8.0
11		24.1		27.5		27.8		26.6		26.2		10.9
12	11.4		10.2		13.0	7.1	14.5		7.6		15.6	5.6
	30.0		30.0									6.0
13	12.2		8.8		14.0	9.9	10.8		7.7		7.4	9.6
	34.5		35.0		32.4		30.7		27.0		13.6	
14	24.5		20.8		20.0	9.4	12.8		18.5		14.5	
15	19.0		20.6		13.2	8.8	11.7		16.1		19.3	9.3
16	31.5		29.0		27.3	12.9			27.0		25.3	8.9
17	28.3	4.5	10.7	13.2	10.8		24.2	7.4	7.1		17.0	7.4
	9.3		9.2			9.6	8.6		7.9			
18	11.0		9.7	9.0		27.2	25.0		11.7			7.5
	28.4		30.5						28.5			
19	21.8			21.9		21.8	21.2		20.5			19.3
	9.0	6.5	8.4	9.6	8.0	8.7	8.0	8.7	7.1	7.9	7.7	8.5
20	26.0						25.3					
21	23.6	14.0	19.2	16.3	14.2	15.2	16.0	17.7	14.8		15.0	10.0
			7.5			8.7	8.0		7.3			
22	20.0		29.5		16.5		26.3		27.3		20.7	14.3
23	10.0	5.0	7.5	8.1	7.7	16.0	8.3	6.5	8.1	6.9	6.1	7.2
24	22.8	4.5	7.6	9.5	9.2	8.4	9.2	8.6	7.6		6.5	8.5
25	14.0		14.6			16.5	15.0		11.6			16.6
26	17.5		27.5		16.4	14.6	14.6		13.9		14.2	17.5
27	21.0		16.2		18.0		20.2		12.8		12.5	
28	11.5	6.0	5.8	6.0	5.0	6.4	11.2	6.5	5.4	6.2	5.7	5.4
		22.8	16.7				31.5	27.5		21.0		15.0
29		34.6										
30	10.0	10.0	9.5	8.9	10.2	14.0	11.0	9.0	11.7		19.6	6.9
31	16.5		12.7		19.3	10.5	25.0			21.0		10.8
32		26.0		23.3		25.7		21.2			23.9	
33		30.5		38.9		27.6		26.3		23.3		27.5
34	28.2	9.7	12.2	10.7	15.1	23.5	26.0	11.7	17.5		9.1	11.8
35	26.7		22.5			25.7	23.5		17.1			13.0
36	7.6	7.6	9.2	8.3	8.5	8.2	6.9	7.1	26.2	8.3		9.5
37	34.0		30.5		31.8	16.2	28.5		15.0		26.2	7.7
			8.3		8.8						8.3	
38			34.0		17.4						29.0	
39	25.5		23.5	18.7		27.9	30.0		30.3			22.6
	9.3	3.5	7.9	9.0	10.0	11.0	10.6	10.5	8.5	12.7	8.5	8.8
40	34.8						35.0					
				9.7								
41	9.0			23.0		6.5	13.9		8.8			9.4
	27.5			34.7								
42	28.5		28.1		27.2	8.8	18.5		17.1		18.7	
43	29.2	11.0	8.9		28.3	10.0	26.0		27.3		18.5	10.2
44	24.0		11.9				10.7			6.9		21.2
45	21.4			29.6		19.2	9.5		20.8			15.8

TABLE I.—Data relating to deliveries of cream and results of tests at Colby, Kans., July 20 to August 1, 1903—Continued.

Patron's number.	Results of acidity tests made of cream delivered on—											Aug. 1.
	July 20.	July 21.	July 22.	July 23.	July 24.	July 25.	July 27.	July 28.	July 29.	July 30.	July 31.	
46	25.4	.....	.....	.....	.....	15.2	.....	.....	30.0	10.7	.....	21.6
47	29.8	.....	20.3	.....	27.7	11.2	26.0	.....	.....	.....	24.2	12.5
48 .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
49	23.3	.....	28.2	.....	27.0	12.7	22.2	.....	20.5	.....	.....	26.0
50 .....	.....	27.2	.....	.....	.....	30.1	.....	.....	.....	.....	.....	.....
51	16.6	.....	12.8	.....	15.2	8.8	9.7	.....	15.6	.....	12.8	.....
52 .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
53	32.8	.....	27.5	.....	25.2	20.0	25.4	.....	21.3	.....	10.4	7.8
54 .....	.....	27.4	.....	25.1	.....	.....	.....	.....	.....	.....	21.6	.....
55	16.6	2.9	.....	.....	9.1	8.3	.....	.....	.....	21.3	.....	8.9
56 .....	.....	.....	.....	.....	17.0	.....	.....	.....	.....	.....	.....	.....
56	10.5	.....	25.5	.....	25.6	10.3	17.5	.....	18.5	.....	12.4	8.9
57	20.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.7
58	23.2	.....	.....	.....	.....	22.5	19.6	.....	.....	.....	.....	.....
59 .....	.....	.....	.....	.....	.....	36.2	.....	.....	.....	.....	30.7	.....
59	35.2	.....	37.0	.....	.....	37.5	.....	38.3	.....	.....	23.9	.....
60	8.0	8.5	7.6	8.5	9.5	8.9	.....	8.2	7.6	.....	16.3	9.4
61	18.5	.....	20.2	.....	21.8	10.3	19.4	.....	.....	.....	.....	16.4
62 .....	.....	.....	.....	.....	.....	15.7	.....	.....	.....	.....	.....	.....
62	24.4	17.1	22.7	15.5	20.6	20.5	29.7	14.5	11.4	17.9	9.5	11.1
63	31.8	24.1	.....	23.6	.....	21.5	.....	22.2	.....	.....	.....	21.7
64	24.0	.....	25.8	.....	24.3	17.8	24.2	.....	21.8	.....	22.7	11.0
65 .....	.....	.....	.....	.....	.....	4.5	8.5	.....	.....	.....	.....	.....
66 .....	.....	.....	.....	.....	.....	10.6	24.9	.....	27.3	.....	.....	.....
67 .....	.....	.....	.....	.....	.....	.....	24.5	.....	29.0	.....	.....	28.6
68 .....	.....	.....	.....	.....	.....	.....	.....	29.8	.....	30.5	.....	14.7

A study of the above table with a view to getting averages shows some interesting things. For convenience of discussion the milkings before delivery will be numbered as follows: The milking of the morning on which delivery is made will be No. 1; the milking of the evening just previous to this will be No. 2; the milking of the morning before the day of delivery will be No. 3; that of the evening before this, No. 4, etc.

Taking the results of all tests known to represent milkings No. 1 or Nos. 1 and 2 mixed, the average degree of acidity is 9.3 for 226 such lots. Taking the cans that might contain Nos. 1, 2, 3, and 4, or Nos. 2, 3, and 4, or Nos. 3 and 4 the average degree of acidity is 22.1 for 260 such lots. Taking the cans supposed to contain milkings Nos. 3, 4, 5, and 6, or Nos. 4, 5, and 6, or Nos. 5 and 6 the average degree of acidity is 29.5 for 25 such lots. Of the class first mentioned 33 out of 226 cans contained enough acid to justify classing them as sour cream—that is, 14 or above. In the second class, 33 out of 260 cans contained less than 14 of acid and would have been classed as sweet cream. In

the third class all were sour. Putting these facts in the form of a table, the following is the result:

TABLE II.—*Showing number of sweet and sour cans delivered.*

Class.	Number of cans.	Sour.	Sweet.	Average acidity.
1.....	226	33	193	9.3
2.....	260	227	33	22.1
3.....	25	25	0	29.5
Total.....	511	285	226	

There was a great variation in the size of the cans used. One-gallon pails, 3-gallon pails, 5-gallon cans, 8-gallon cans, and 10-gallon cans were used in the delivery. The total quantity of cream received per week was between 1,100 and 1,200 gallons. Of the total received in the two weeks, from 30 to 50 per cent each day was sweet. This varied considerably with the days, Mondays showing the most sour cream and Saturdays the most sweet cream. Taking the total for each week's receipts, the sweet cream averaged about 33½ per cent. A study of Table I will show that the cream of the last week was not so sour as that of the first, and that the last two or three days showed the best results of all. It is interesting to note the temperature of these days and its evident effect on cream. Table III shows the maximum and minimum temperatures for each day covered by Table I, the average for the month of July, and the average during July for the ten years previous. This data is taken from the records at Colby made for the United States Department of Agriculture. The average acidity of the day's receipts of cream is also given.

TABLE III.—*Showing maximum and minimum temperatures, and acidity of cream.*

	Temperature.		Average acidity of cream.
	Maximum.	Minimum.	
July 20.....	100	56	21.3
July 21.....	96	61	13.5
July 22.....	98	65	18.6
July 23.....	93	65	17.8
July 24.....	94	65	18.1
July 25.....	97	61	15.5
July 27.....	95	61	18.7
July 28.....	98	58	14.1
July 29.....	91	54	16.7
July 30.....	77	58	14.5
July 31.....	62	52	16.5
August 1.....	77	55	12.4
Average, July, 1903.....	90.4	59.7	
Average, July, 10 years.....	90.9	59.2	

It must be understood in studying these figures that they are only approximations of the average acidity. The figures in Table I show

the exact acidity of each can delivered, but the weight of cream is not recorded. The results, so far as acidity is concerned, are therefore averages of Table I and can not be taken to mean more than that. They do, however, in a general way give the truth of the matter and show the tendency as influenced by the various factors given. For instance, in Table III the maximum temperature on the 20th was 100° and the degree of acidity 21.3; on the 27th the maximum was 95° and the acidity 18.7; on the 21st it reached 96° but the acidity was only 13.5, and on the 28th the highest temperature was 98° and the acidity 14.1. This shows simply that the factor of temperature has considerable influence on the acidity of the cream.

Another thing must be taken into account in the study of these figures: Not one in ten farmers had any good way to keep his cream sweet, and the weather showed its influence more than it would have done had every farmer owned a good tank and a mill pumping cold water about the cans all the time. The average temperatures for the first week in the above table are above the average for the Julys of the ten previous years, while for the last week they are below this average. Nearly an inch of rain fell on the 30th of July, which accounted for the cool weather of that day and the day following. The cream received on these days was in excellent condition, over 50 per cent of it being perfectly sweet.

A further study of Table I will show that a few patrons delivered sweet cream when coming every other day. These few were those who had a place fixed for holding their cream so that they could cool it quickly and hold it cool until delivered. The average well-water temperature of the vicinity of Colby is about 60°, and cream held at this temperature was delivered sweet 48 hours old. What these few did every man could have done, for all had the same sunshine and shade, the same winds and water—in fact, the same natural conditions—which are remarkably uniform in this western country.

Table I shows also the irregular methods which are followed in the delivery of cream, many seeming to have no regular time, while a few are as regular as the days of the week. This condition exists all over the territory under discussion, the delivery of cream being made a matter of convenience to the farmer rather than a necessity on account of the cream.

V. THE CREAMERY SIDE OF THE SUBJECT.

THE CREAMERY'S RESPONSIBILITY.

Thus far the discussion of this question of quality has been from the farmer's standpoint. The recommendations given in the first part of this bulletin for the handling and care of cream result from the experience gained at the Colby station while conducting the investigations there, from experience in other parts of Kansas and Nebraska, and from observation and consultation with men in the field who

are well informed on its conditions. The conditions at Colby are much the same as elsewhere. The farmer needs facilities for doing his work and needs the incentive to do it right. All of the cream at this point brought the farmer the same price, no matter what its condition. The patron who would take pains to furnish good cream saw it dumped into the same receptacle with other cream that he knew was inferior in quality. Under this condition—and it was the universal condition at least up to January 1, 1904—there was but little use for the creamery companies to talk about quality to the farmer. The object lesson of the stations and the system of buying cream was all against quality, and yet the creamery man who did not lay all of his troubles on the farmer was the exception. The creamery companies were doing, in a way, what they could to get good cream, and they spent more time on the farmer than they did on that part of the business that was in their own hands. The creamery men are not to be blamed too much, perhaps, for this condition, but to a certain extent they are at fault.

As was pointed out in the first part of this work, the creamery men fought the introduction of the farm separator until they had to give in. They put in time arguing that the separator on the farm would be a bad thing, instead of going to the heart of the question and making a study of the new conditions brought about by the farm machine. When the quality of butter "went off," as it did, a sort of "I told you so" feeling was expressed by the creamery men to the dairy editor and even to the dairy-school worker. All were busy telling the bad things the separator would do, but none could offer anything, or seemingly tried to offer anything, that would help the bad condition, except to pitch into the farmer, first, because he bought a machine, and then because he furnished cream that was making bad butter. This was, perhaps, natural; it was easy, at any rate, because the farmer bought the machine under protest. When the creamery men first turned their attention to the matter and found that they had to sell machines or quit the business, they did what could not be helped under existing conditions—they put scores of agents into the field, and the order was "sell machines." The result was, to put it in the language of the superintendent of one of the large creameries, that "in the transition from the whole milk to the hand separator business, in spite of the fact that we urged the delivery of cream at the station with sufficient frequency to insure good cream, the business, in a sense, has gotten away from us." As before stated, neither the farmer nor the creamery man was ready for the change; neither understood the conditions that would arise under the change; and so far the farmer has received most of the blame. Let him take home all that is due him, but let the creamery operator learn that the poor butter has resulted as much from his lack of facilities and knowl-

edge of how best to handle the cream when it came into his care as from the farmer's shortcomings.

The past few months have shown some great advancement on the part of the creameries in this respect. The whole subject is studied as never before. New ideas are put into practice and new methods are used in the factories. Much of this is in the experimental stage as yet and needs time to develop its worth. From some quarters have come remarks deprecating any effort on the part of the creamery to improve the quality of the cream after it has once deteriorated in value. Theoretically this may be all right; the cream ought not to need improving, but the creamery that tries to improve the quality will find its own shortcomings more quickly and will learn that the farmer should not bear all the blame. Let the effort to improve all along the line go on; there is surely great need for it.

CLEANLINESS OF STATIONS.

Too much stress can not be laid upon cleanliness, which has already been mentioned several times. A dirty station or factory is no more excusable than a dirty farm separator. One is just as responsible for the poor quality of product as the other. Indeed, uncleanness at a receiving station has a wider influence for evil than on a single farm; a dirty station may undo the work of a number of clean farms. Station men, as a class, are paid about as well as school-teachers, railroad station agents, or telegraph operators. The prevailing practice is to pay them a commission for what business they handle. This, no doubt, makes them hustle for more business, but some evil effects go along with it. In the first place, these men are not trained in the creamery business. They do not know the value of cleanly methods and premises. This point has not been urged strongly enough on them by those superintending their work. They do not feel the necessity of spending enough time to keep things clean, but feel rather that when they have secured business their responsibility ceases. This is a matter that needs the careful attention of creamery managers all over the territory under discussion.

THE CREAM-PASTEURIZING STATION.

In the handling of the cream between the farmer and the creamery there are four general methods in use: (1) By a cream-pasteurizing station; (2) by a cream station without pasteurizing; (3) by handling cream through a store; (4) by direct shipment.

During the year 1903 there were but two companies west of the Missouri River handling their business by the first of these methods. It was fortunately one of these that received the cream from Colby, Kans., and this afforded an opportunity for the investigations carried on at that point to include considerable work along the line of pasteurizing sweet and sour cream for shipment and noting the result on quality. Much information was gathered, but owing to the many

things to be taken into consideration not many conclusions could be drawn from this work.

THE CREAM STATION WITHOUT PASTEURIZING.

All that has been said about cleanliness and care in the work of the pasteurizing station applies to the simple receiving station. The receiving station must have some method for making steam or boiling water, because steam or boiling water is absolutely essential for keeping things clean. Scores of such stations visited had nothing better for this purpose than a small gasoline stove. One company recently equipped a large number of this kind of stations with small feed-cooker boilers, which ought to answer the purpose very well. In managing this kind of a station, the cream should be graded, the best being put into cans by itself, and the poorer grades each by itself. It will all have about the same acidity when it arrives at the factory, but often cream that is sour when delivered at the station has already developed some other things besides acidity which are worse for the general quality of the butter than the fact that the cream is sour. Owing to this fact the cream should be just as carefully graded as in the pasteurizing station. The effect of shipment on unpasteurized cream in the development of acidity and on its score will be shown further on (pages 37 and 38).

HANDLING CREAM THROUGH A STORE.

At present this is the abomination of the creamery business. Under the present system it has nothing to commend it, but everything to condemn it. The storekeeper has neither the time nor the inclination to give the business the attention required. If he goes into it at all, it is to get trade; therefore he dare not refuse bad cream. He dare not offend a patron in any way. He is at the entire mercy of the patron, just as he has been for years in buying country butter. He has to take what is offered, be it good or bad, or lose a customer. If he uses the cream business as a means of advertising, he is apt to run the price of butter fat up to a fictitious value, thus creating a false impression of the business. He is rarely equipped with facilities of any kind for doing the business properly. In fact, he is a pirate, destroying other men's business for the sake of getting a little advertising for himself, and finally, becoming disgusted with the whole thing, he drops it, leaving the territory in which his injudicious operations were performed in a chaotic state, and causing some legitimate creamery men much expense in again putting the business on a sure and solid footing. If cream were not of so perishable a nature and the storekeeper could handle it as he does potatoes or apples, it might be a different matter.

The result of the store operation will be to destroy itself. Markets can not be found long that will pay a price for the inferior goods offered. With the market gone and the competitor next to him in the shape of a creamery man paying good prices for good cream, the life

of a storekeeper in the business will be of few days and full of sorrow. There is a possibility of a merchant handling the cream as efficiently as a special agent of the creamery, but the chances are 99 in 100 against his doing so. An extended observation of several months has revealed very few such. In many instances the storekeeper was getting all of the poor cream, and was having a hard time to satisfy the parties to whom he sold. The storekeeper will pass as a transitory figure in the great change from whole milk to farm cream separators.

THE DIRECT SHIPPER.

So far as quality is concerned, the direct shipper never has an equal chance with his neighbor who delivers to a near-by station. The direct shipper must hold his cream until he has a full can—5, 8, or 10 gallons—or else the expense of shipping is greater and his profits are reduced. The man who milks a large number of cows and can ship a can every day, or every two days at most, can furnish his creamery with as good cream as anyone, but there are few of this kind of shippers in the West.

The creamery run on this plan seldom adds anything materially to the development of the dairy business, unless it be in new territory. It can dip in here and there and get quite a patronage from disgruntled individuals who are dissatisfied with their home creamery and will go anywhere for a change. It is not meant to speak disparagingly of anyone in the direct shipping business, but these statements are made because observations over two great dairy States show it to be a fact that the greater part of the patronage of this kind of factory is of this class. The quality of such cream during the hot weather—and this is about seven months of the year—is bound to be inferior to that handled through stations. The author can suggest no remedy for this unless it be to ship oftener, which is a financial impossibility in the working of the system. During the winter months the direct shipper is on a more nearly equal footing. There is a time in the development of new territory when the business can be conducted by direct shipping methods. This is when the patronage is too small to justify the operation of a cream-receiving station. In such instances—and there are a good many where the dairy business is extending in new territory—there is nothing to be said against the system so long as it remains in that stage of development. This does not imply that good cream can be so secured, but it means giving a market to those who would not in any other way have one. As soon as such territory is sufficiently developed the station system will give the best results to both farmer and creamery.

TRANSPORTATION OF CREAM.

In the present stage of the business the only refrigerator-car service furnished by the railroads is to the companies operating a sufficiently large number of stations along a line to make up a car of cream before

it reaches the factory. Without doubt, as the business develops and dairying becomes more and more of a regular occupation, it will become incumbent upon the railroads to run refrigerator express cars for the general dairy interests along their lines. No comparison can be made between the refrigerator service and shipping without refrigeration that is at all favorable to the latter. If cream is subjected to such heating as it gets in the ordinary express or baggage car, or in a box car, it responds by fermenting very rapidly, and the loss in quality is exceedingly great. Many of the so-called refrigerator cars in the service are but makeshifts. The doors open at every station to load from 20 to 100 cans of cream, and the car is rapidly warmed. There ought to be a center vestibule made so that it could be closed to the outside air when the refrigerator compartment was opened to admit the cream. Better service along this line, and much better facilities for cooling and keeping the cream cool at the stations, would do much toward securing a good quality of cream.

VI. EXPERIMENTS IN SHIPPING CREAM.

The following tables give the data of the experimental work in shipping cream from the Colby station to Topeka, Kans. The cream was received and graded at the station, part of it being pasteurized and part shipped raw. The tables will explain themselves so far as the data collected is concerned. The author did the work at the station and was assisted by Mr. C. E. Gray at the factory in Topeka.

SHIPMENTS OF PASTEURIZED AND UNPASTEURIZED CREAM.

All of the cans numbered from 1 to 115, inclusive, were shipped during the last few days in July. The results were very unsatisfactory, but the data are given for these shipments because there are a few facts brought out that had considerable bearing on the later work.

TABLE IV.—*Data relating to shipments of cream from Colby to Topeka, Kans., July 20 to 29, 1903.*

SHIPMENTS OF PASTEURIZED CREAM.

No. of can.	July—	Time on road.	Station temperature.	Factory temperature.	Station acidity.	Factory acidity.	Butter fat.	Station grade.	Factory grade.
		Hours.	° F.	° F.			Per cent.		
1.....	20	72	66	68	19.2	33.1	31.7	1	2
2.....	20	72	62	68	23.7	31.2	34.4	2	2b
3.....	20	72	70	68	23.0	36.1	35.5	1	2b
5.....	20	72	66	66	26.2	32.1	33.1	1	2b
6.....	20	72	78	68	9.0	37.5	31.2	1b	3a
7.....	21	72	64	60	9.7	33.4	34.2	1	2b
8.....	21	72	63	61	9.7	33.6	34.4	1	2b
9.....	21	72	63	62	9.7	31.6	35.6	1	2b
11.....	21	72	64	62	27.3	26.7	35.8	2	2c
12.....	22	72	62	63	10.5	36.0	31.8	1	2a
13.....	22	72	62	66	12.3	34.4	32.1	1	2c
14.....	22	72	62	63	25.6	34.2	32.1	2	3b
15.....	22	72	62	65	30.0	34.0	32.1	2	3c

TABLE IV.—Data relating to shipments of cream from Colby to Topeka, Kans., July 20 to 29, 1903—Continued.

SHIPMENTS OF PASTEURIZED CREAM—Continued.

No. of can.	July—	Time on road.	Station temperature.	Factory temperature.	Station acidity.	Factory acidity.	Butter fat.	Station grade.	Factory grade.
		Hours.	° F.	° F.			Per cent.		
16.....	24	32	72	70	13.2	13.5	36.2	1	1a
17.....	24	32	70	70	13.0	14.0	38.0	1	1a
18.....	24	32	70	70	14.8	15.8	37.0	1	2
19.....	24	32	70	70	17.0	17.0	37.6	2	2
20.....	24	32	72	70	16.2	16.5	37.4	2	2b
21.....	24	32	82	70	17.5	18.0	38.6	2	2
22.....	24	32	68	70	17.2	28.0	29.8	2	2b
23.....	24	32	76	70	18.6	18.6	30.7	2	2b
24.....	24	32	70	70	19.6	18.5	32.7	2	2c
25.....	24	32	68	70	19.3	16.8	30.9	2	2
26.....	24	32	62	70	18.3	17.5	32.6	2	2
27.....	24	32	62	70	18.6	18.0	33.6	2	2
28.....	24	32	70	70	18.2	18.2	32.1	2	2
29.....	24	32	72	70	24.2	22.2	32.0	3	2
30.....	24	32	72	70	27.6	23.5	34.6	3	3
31.....	24	32	72	70	28.7	24.0	35.0	3	2
32.....	24	32	70	70	29.5	26.0	34.6	3	2
33.....	24	32	68	70	29.7	24.0	34.6	3	2
34.....	25	58	66	66	12.2	30.0	34.8	1	2
35.....	25	58	66	72	10.8	36.4	32.2	1	3
36.....	25	58	66	66	9.7	31.5	35.5	1	3
37.....	25	58	67	72	10.5	31.5	36.6	1	3
38.....	25	58	68	72	9.0	37.0	32.8	1	3
39.....	25	58	77	72	8.4	33.8	35.0	1	3
40.....	25	58	68	72	10.3	37.5	33.4	1	3
41.....	25	58	74	72	11.1	35.7	31.8	1	3
42.....	25	58	74	72	14.2	39.9	32.0	1	3
43.....	25	58	72	72	14.0	31.3	32.3	1	3
44.....	25	58	68	72	14.2	31.8	31.8	1	3
45.....	25	58	72	72	14.7	33.6	32.8	1	3
46.....	25	58	73	66	23.3	24.2	34.6	3	3
47.....	25	58	72	72	26.4	35.5	35.7	3	3
48.....	25	58	74	72	26.2	31.0	35.3	3	3
49.....	25	58	78	64	26.0	35.8	29.0	3	3
50.....	25	58	71	64	26.2	28.0	35.1	3	3
51.....	25	58	74	72	26.4	31.0	33.6	3	3
52.....	25	58	76	65	26.0	30.8	33.8	3	3
53.....	25	58	70	66	26.2	30.0	36.2	3	3
54.....	25	58	71	72	26.2	32.0	34.4	3	3
55.....	27	34	66	76	11.6	20.0	37.0	1	2c
57.....	27	34	66	76	11.1	24.0	35.0	1	2c
59.....	27	34	65	76	11.2	22.0	34.6	1	2b
61.....	27	34	66	76	10.0	25.0	33.8	1	2c
63.....	27	34	74	76	10.0	36.0	32.7	1	3
65.....	27	34	68	76	10.6	27.0	34.0	1b	2c
67.....	27	34	66	76	18.7	36.0	34.5	2	3
69.....	27	34	68	76	23.7	28.0	33.6	3	2c
71.....	27	34	66	76	25.1	22.0	32.2	3	2c
73.....	27	34	66	76	24.9	24.0	31.5	3	2c
75.....	27	34	66	76	25.9	25.0	28.1	3	3
77.....	27	34	71	76	26.0	25.0	32.2	3	2c
79.....	27	34	71	76	25.4	28.0	32.3	3	2a
81.....	27	34	76	76	23.2	27.0	21.5	3	3

TABLE IV.—Data relating to shipments of cream from Colby to Topeka, Kans., July 20 to 29, 1903—Continued.

SHIPMENTS OF PASTEURIZED CREAM—Continued.

No. of can.	July—	Time on road.	Station temperature.	Factory temperature.	Station acidity.	Factory acidity.	Butter fat.	Station grade.	Factory grade.
		Hours.	° F.	° F.			Per cent.		
82.....	27	34	76	76	13.9	30.0	36.3	3	3
83.....	28	34	66	72	9.8	23.6	32.0	1	2a
85.....	28	34	68	72	9.4	20.5	34.7	1	2a
87.....	28	34	74	72	26.2	25.0	30.7	3	2b
89.....	28	34	70	72	27.9	33.0	33.2	3	2b
91.....	29	34	64	66	7.4	11.5	29.2	1	2a
92.....	29	34	64	66	7.7	8.0	35.6	1	2b
93.....	29	34	67	66	8.4	9.0	36.5	1	2b
94.....	29	34	68	66	8.2	9.0	36.8	1	2c
95.....	29	34	66	66	8.3	9.0	35.8	1	2a
96.....	29	34	66	66	8.4	10.0	35.8	1	2a
97.....	29	34	70	68	8.9	10.5	34.8	1	2b
98.....	29	34	66	66	10.5	12.0	33.0	1	2
99.....	29	34	66	66	13.5	12.0	32.6	1	2
100.....	29	34	75	66	14.2	14.2	30.4	1b	2b
101.....	29	34	70	66	15.5	14.0	31.4	2	2b
102.....	29	34	66	66	19.5	17.5	31.6	2	2a
103.....	29	34	67	66	25.3	35.0	32.4	3	2a
105.....	29	34	69	66	27.8	24.5	33.0	2b	2b
107.....	29	34	68	66	28.1	27.0	32.8	3	2b
109.....	29	34	64	66	27.9	25.0	32.8	3	2c
111.....	29	34	68	66	27.3	24.0	32.0	3	2b
113.....	29	34	70	66	27.0	24.0	30.4	3	2c
115.....	29	34	70	66	8.8	25.5	40.6	1	2a

SHIPMENTS OF RAW CREAM.

4.....	20	72	78	68	27.6	40.7	31.6	2	4a
10.....	21	72	82	62	29.0	38.5	32.4	2	3
56.....	27	34	72	76	13.1	32.0	37.5	1	2
58.....	27	34	70	76	12.1	32.0	36.8	1	3
60.....	27	34	75	76	14.1	31.0	33.2	1b	2
62.....	27	34	74	76	11.6	34.0	34.8	1	2b
64.....	27	34	74	76	11.5	33.0	34.0	1	2b
66.....	27	34	73	76	24.3	37.0	33.0	2	2b
68.....	27	34	74	76	22.5	42.0	33.8	2b	3
70.....	27	34	76	76	24.2	37.0	32.8	2b	3
72.....	27	34	78	76	25.9	38.0	33.0	2b	3a
74.....	27	34	77	76	26.5	42.0	32.8	2b	3
76.....	27	34	78	76	25.7	39.0	32.2	1b	2c
78.....	27	34	78	76	25.7	41.0	32.1	2	3
80.....	27	34	79	76	25.7	39.0	32.4	2b	3
81.....	28	34	74	64	9.8	32.0	34.4	1	2c
86.....	28	34	76	64	8.5	32.0	36.0	1	2c
88.....	28	34	80	64	26.0	34.0	35.4	2b	2c
90.....	28	34	84	64	28.9	47.5	32.8	3	3d
104.....	29	34	77	66	26.3	32.0	31.2	2	2b
106.....	29	34	74	66	28.9	26.0	33.0	3	3b
108.....	29	34	76	66	27.2	34.5	30.0	3	3
110.....	29	34	76	66	27.0	36.0	30.4	3	3
112.....	29	34	78	66	27.2	35.0	30.0	3	2c
114.....	29	34	78	66	30.3	37.0	36.6	3b	3a

The following explanations will be necessary for a clear understanding of the preceding table. The cans were numbered from 1 consecutively throughout the entire investigation, these numbers appearing in the first column. The date on which the cream was received at the station appears in the second column. The column headed "Time on road" indicates the number of hours between the receipt of the cream at the station and its arrival at the factory. The temperature was taken and the acid test was made at the station as the cream came from the pasteurizer, or, in the case of raw cream, as it was poured into the cans for shipment. The temperature was again taken and the acidity test was repeated on arrival at the factory. The cream was graded at the station and at the factory on the following basis:

Grade 1 represented cream that would score 96 points on a scale of 100 for perfection, or, in other words, cream that would be expected to make butter that would score 96; grade 2 represented cream that would score 92; grade 3, that which would score 88; and grade 4, that which would score 84. The letters "a," "b," and "c" were used for the intervening grades between 96, 92, 88, and 84, "a" representing 1 point less, "b" 2 points less, and "c" 3 points less. Thus "1a" would mean 95, "1b" 94, and "1c" 93. The grading was done by two different persons nearly three hundred miles apart, and it took some time to get this part of the work uniform. It is owing to this and to the fact that much of the cream was three days on the road that no definite conclusion can be drawn from this set of figures.

Cans Nos. 116 to 258, inclusive, were shipped August 17-31. During this period the railroad facilities were better than at the time of the first shipments, and a few things were avoided which then caused irregular work. The data given in Table V are in the same order as in Table IV. A change in the method of making the acid test was made. The tests in Table IV were made with a 50-c. c. pipette, while those in the following tables were made by weighing 18 grams of cream into the cup. The weighing was made necessary from the fact that the pipette would not give a full measure when the cream was taken immediately after going through the pasteurizer and cooler, nor at the factory, where the cream would in many instances have more or less gas in it. Weighing the sample and calculating the result to 50 c. c. gave more uniform results. The grading in the tables following was also much more uniform and satisfactory.

TABLE V.—Data relating to shipments of pasteurized cream, one day on the road, from Colby to Topeka, Kans., August 17-28, 1903.

No. of can.	August—	Time on road.	Station temperature.	Factory temperature.	Station acidity.	Factory acidity.	Butter fat.	Station grade.	Factory grade.
		Hours.	° F.	° F.			Per cent.		
116.....	17	23	66	74	12.0	15.7	33.0	1	1a
117.....	17	23	64	74	13.4	15.4	32.0	1	2a
120.....	17	23	66	74	14.2	16.6	32.8	1b	2b
122.....	17	23	67	74	14.8	15.2	33.4	1	2b
125.....	17	23	68	74	13.1	14.7	38.8	1	2
127.....	17	23	88	74	15.1	24.4	37.8	1	2
141.....	18	24	70	78	7.8	29.1	37.6	1	3a
142.....	18	24	70	78	7.8	29.9	34.2	1	3a
145.....	18	24	72	80	7.2	29.4	41.2	1	3a
145b.....	19	23	68	75	9.8	35.0	34.0	1	3
146b.....	19	23	66	75	9.2	33.6	35.6	1	2b
147b.....	19	23	66	75	13.4	28.0	35.6	1	1b
148b.....	19	23	72	75	13.1	30.8	35.8	1	2
157.....	19	23	70	75	11.7	42.0	37.4	1	2
168.....	20	26	76	72	7.8	11.2	33.4	1	3
169.....	20	26	68	72	8.4	8.4	35.6	1	2
170.....	20	26	72	72	7.8	11.2	34.5	1	1c
172.....	20	26	82	72	6.7	19.6	42.6	1	2
173.....	20	26	74	72	7.0	18.2	39.2	1	2c
180.....	21	24	74	68	8.1	15.9	32.2	1	1c
181.....	21	24	74	68	9.5	11.2	32.0	1	1c
182.....	21	24	68	68	12.6	13.1	33.0	1	1b
185.....	21	24	68	68	13.1	13.7	31.4	1	1b
187.....	21	24	68	68	12.6	12.8	33.6	1	2a
188.....	21	24	72	70	11.7	12.3	34.9	1	1c
189.....	21	24	70	72	12.0	12.3	28.0	1	1c
191.....	21	24	68	68	12.6	13.4	26.7	1	1c
198.....	22	26	68	72	10.3	12.0	34.8	1	1b
199.....	22	26	68	72	9.8	12.0	34.4	1	2c
200.....	22	26	68	72	9.8	12.0	34.7	1	1b
201.....	22	26	74	72	10.7	33.0	36.4	1	1b
202.....	22	26	68	72	11.2	12.0	39.3	1	2a
203.....	22	26	68	72	10.6	11.0	35.5	1	3c
204.....	22	26	72	72	8.6	15.0	35.0	1	1c
207.....	22	26	72	72	8.9	29.0	36.4	1	2b
221.....	26	24	70	70	8.9	9.5	34.2	1	1b
222.....	26	24	72	70	9.8	11.2	33.6	1	1c
223.....	26	24	65	68	9.8	10.0	38.8	1	1c
225.....	26	24	68	68	10.0	10.6	34.5	1	1c
227.....	26	24	66	68	11.7	12.6	33.8	1	1c
229.....	26	24	70	70	14.0	15.4	37.8	1	2a
230.....	26	24	68	68	16.5	17.0	35.4	1	2a
231.....	27	24	74	68	9.5	11.2	33.5	1	2a
232.....	27	24	76	66	10.9	11.4	38.4	1	1c
233.....	27	24	68	66	10.9	10.9	38.5	1	1b
234.....	27	24	68	66	9.2	9.8	35.5	1	2a
235.....	28	24	65	64	6.7	7.0	33.8	1	1b
236.....	28	24	64	66	7.2	7.5	33.6	1	1b
237.....	28	24	64	64	9.5	9.8	36.8	1	1b
238.....	28	24	66	64	8.1	8.1	35.8	1	1b
239.....	28	24	64	64	8.9	9.2	35.8	1	1b
240.....	28	24	72	66	9.5	9.8	40.0	1	1c
241.....	28	24	70	64	7.8	7.8	40.0	1	1a
Average for 53 cans.....					10.2	16.1	35.3	95.97	91.96
Average for 18 cans, August 26-28.....					9.9	10.4	36.1	96.00	93.08

TABLE VI.—Data relating to shipments of pasteurized cream, two days on the road, from Colby to Topeka, Kans., August 17-22, 1903.

No. of can.	August—	Time on road.	Station temperature.	Factory temperature.	Station acidity.	Factory acidity.	Butter fat.	Station grade.	Factory grade.
		<i>Hours.</i>	<i>° F.</i>	<i>° F.</i>			<i>Per cent.</i>		
128.....	17	44	70	75	19.8	22.4	36.6	1c	2c
129.....	17	44	76	75	18.7	19.3	34.0	1c	2c
130.....	17	44	76	74	16.5	31.0	37.0	1c	2c
131.....	17	44	72	74	8.6	31.3	39.8	1	3a
146.....	18	44	67	75	7.2	29.4	35.6	1	2c
159.....	19	48	68	72	9.2	32.2	38.6	1	1b
160.....	19	48	68	72	8.9	32.2	36.4	1	2c
161.....	19	48	71	72	8.6	28.0	35.6	1	2b
162.....	19	48	73	72	17.9	30.8	34.2	1c	1c
163.....	19	43	74	72	10.9	29.4	27.8	1	2c
192.....	21	48	68	72	14.5	36.0	29.2	1a	2c
193.....	21	48	68	72	15.9	33.0	32.4	1a	2c
194.....	21	48	68	72	15.4	29.5	33.4	1a	2a
196.....	21	48	68	72	14.2	31.0	36.6	1a	2b
214.....	22	42	74	68	10.9	37.5	34.5	1	3a
215.....	22	42	70	68	12.0	33.6	34.5	1	3a
216.....	22	42	74	68	7.8	29.4	28.4	1	3b
217.....	22	42	76	68	6.4	34.4	35.4	1	4c
218.....	22	42	86	68	10.0	36.4	33.4	1	3a
Average for 19 cans.....					12.2	30.8	34.4	95.16	88.76

TABLE VII.—Data relating to shipments of unpasteurized cream, one day on the road, from Colby to Topeka, Kans., August 17-31, 1903.

No. of can.	August—	Time on road.	Station temperature.	Factory temperature.	Station acidity.	Factory acidity.	Butter fat.	Station grade.	Factory grade.
		<i>Hours.</i>	<i>° F.</i>	<i>° F.</i>			<i>Per cent.</i>		
118.....	17	23	64	74	25.5	31.6	33.8	1b	1b
119.....	17	23	68	74	23.0	32.7	39.6	1b	1b
121.....	17	23	68	74	28.9	38.2	32.2	2	2
123.....	17	23	68	74	26.1	35.5	31.4	2	3
124.....	17	23	75	74	25.2	34.0	41.8	1c	2c
126.....	17	23	74	74	22.1	29.8	39.0	1	2
140.....	18	24	74	77	20.7	37.2	43.4	1	2a
143.....	18	24	68	77	28.0	32.2	36.8	2a	2c
144.....	18	24	76	78	29.4	52.3	37.0	1b	4a
149.....	19	23	72	75	25.7	37.8	34.6	1b	2a
151.....	19	23	66	75	32.2	37.8	37.0	2	3
152.....	19	23	72	75	29.4	44.8	32.6	1b	4
153.....	19	23	72	75	27.1	39.2	35.0	1b	2a
154.....	19	23	74	75	28.5	42.0	35.4	1b	2
155.....	19	23	80	75	30.2	46.2	31.6	1b	3
156.....	19	23	76	75	24.6	37.8	32.6	1b	2a
158.....	19	23	72	75	25.4	37.8	32.8	1c	1c
171.....	20	26	76	72	21.5	26.6	39.2	1	2c
174.....	20	26	79	72	18.2	30.8	38.6	1	1c
183.....	21	24	75	74	24.3	31.6	39.4	1b	2a
184.....	21	24	76	74	27.1	36.9	31.0	2	2a
186.....	21	24	70	72	27.1	33.0	32.0	2c	2c
190.....	21	24	76	72	17.3	27.1	38.5	1c	2a
205.....	22	26	86	72	22.6	31.5	28.9	1b	2b
206.....	22	26	76	72	26.6	35.5	37.0	1a	2a
224.....	26	21	70	68	19.6	26.6	33.8	1b	2a
226.....	26	21	68	68	25.0	36.8	28.0	1c	2c
228.....	26	21	68	68	27.4	33.0	32.4	2b	2c
242.....	29	24	66	64	7.2	28.8	36.6	1	2b

TABLE VII.—Data relating to shipments of unpasteurized cream, one day on the road, from Colby to Topeka, Kans., August 17–31, 1903—Continued.

No. of can.	August—	Time on road.	Station temperature.	Factory temperature.	Station acidity.	Factory acidity.	Butter fat.	Station grade.	Factory grade.
		Hours.	° F.	° F.			Per cent.		
243.....	29	24	66	64	7.2	29.4	35.2	1	2b
244.....	29	24	66	64	7.2	28.5	36.4	1	2c
245.....	29	24	66	64	8.1	29.9	32.4	1	2b
246.....	29	24	70	64	16.8	32.4	37.0	1c	2a
247.....	29	24	68	64	8.1	29.4	37.9	1	2c
248.....	29	24	66	64	9.8	32.4	32.4	1	2c
249.....	29	24	66	64	22.4	33.0	29.7	2	3b
250.....	29	24	65	64	21.0	33.0	32.2	1c	2a
251.....	29	24	66	64	23.8	36.2	37.8	2	2a
252.....	31	22	67	64	10.0	29.9	35.6	1	2b
253.....	31	22	67	64	10.0	29.4	34.7	1	2b
254.....	31	22	67	64	10.0	29.0	34.2	1	2b
255.....	31	22	68	64	25.7	30.8	37.4	1c	2c
256.....	31	22	69	64	31.3	36.4	31.7	2a	2c
257.....	31	22	67	64	10.0	31.2	33.0	1	2c
258.....	31	22	67	64	9.5	29.1	36.4	1	2a
Averages for 45 cans.....					21.0	33.8	35.0	93.96	89.96
Average for 17 cans, August 29–31.....					14.0	31.1	34.7	94.72	89.68

TABLE VIII.—Data relating to shipments of unpasteurized cream, two days on the road, from Colby to Topeka, Kans., August 17–22, 1903.

No. of can.	August—	Time on road.	Station temperature.	Factory temperature.	Station acidity.	Factory acidity.	Butter fat.	Station grade.	Factory grade.
		Hours.	° F.	° F.			Per cent.		
132.....	17	44	66	74	22.6	28.5	34.0	2	3a
133.....	17	44	71	74	27.1	36.9	33.4	2	3b
134.....	17	44	71	76	20.7	31.6	35.0	1c	4a
135.....	17	44	70	74	26.8	36.9	32.0	2	3b
136.....	17	44	70	74	26.8	39.4	27.6	2	3a
137.....	17	44	68	74	21.2	30.5	36.4	2	3a
138.....	17	44	73	74	22.9	43.9	45.2	2	4a
139.....	17	44	68	74	29.4	41.1	28.4	3	3c
147.....	18	44	73	75	26.6	33.6	37.8	1a	2
148.....	18	44	70	75	26.8	47.6	35.6	1b	3b
143b.....	18	44	76	75	27.1	40.6	35.0	1c	3
144b.....	18	44	71	75	30.5	37.8	31.4	1c	2b
164.....	19	48	68	72	24.3	37.8	35.0	1	3
165.....	19	48	72	72	24.0	37.8	32.6	1a	3b
166.....	19	48	78	72	18.4	28.0	41.6	1b	2
167.....	19	48	78	68	27.4	40.6	34.4	1b	3
175.....	20	45	71	68	23.2	35.0	33.5	1a	2c
176.....	20	45	74	68	29.4	44.5	31.4	1b	4a
177.....	20	45	77	68	24.6	35.0	38.4	1c	3a
178.....	20	45	74	68	22.1	35.5	33.9	2	2b
179.....	20	45	68	68	22.4	30.2	37.4	2c	2b
195.....	21	48	74	72	25.4	34.5	38.5	1b	3c
197.....	21	48	74	72	23.8	35.5	36.0	1b	2b
208.....	22	42	82	68	28.5	46.4	36.0	1	4a
209.....	22	42	82	68	28.2	38.9	37.8	1	3a
210.....	22	42	82	68	28.0	45.6	36.0	2	3b
211.....	22	42	82	68	27.4	38.3	35.6	1c	3a
212.....	22	42	78	68	28.0	38.9	38.2	1	3b
213.....	22	42	82	68	29.4	43.9	39.2	1a	3b
219.....	22	42	82	68	24.9	35.2	36.9	1a	3a
220.....	22	42	72	68	55.2	65.8	29.2	4	4a
Average for 31 cans.....					26.5	38.5	35.2	92.02	86.88

A few general ideas can be derived from the above tables. The temperature of pasteurization varied from 170° to 180° and the cream was immediately cooled to the temperatures named under the heading "Station temperature." The Jensen pasteurizer and cooler was used.

A glance at the tables will show that the cream was divided into sweet and sour, the turning point being 14. All of the sweet cream was pasteurized and all of the sour cream shipped raw until August 29, when an accident befell the pasteurizer and all of the cream of the 29th and 31st was shipped raw.

EFFECT OF PASTEURIZING ON THE KEEPING QUALITIES OF SWEET CREAM.

Table V shows that cream testing an average of 10.21 of acidity when pasteurized was found on arrival at destination twenty-four hours later to have increased in acidity 5.93, so as to measure 16.14. Cream at this acidity is slightly sour. The average score at the station, on the basis of 100 as perfect, was 95.97, while at the factory it was 91.96. Comparing this with the cream that was two days in transit, as shown in Table VI, quite a difference will be noted. This cream started under conditions practically equal to those of the cream which was one day in transit. The degree of acidity at the station was 12.28, and on arrival at the factory forty-eight hours later it had increased 18.06 or to 30.88. The score had fallen from 95.16 to 88.76. The temperatures on arrival at the factory show that this difference was not due to that factor. The shipments were all made in refrigerated cars and the conditions were about equal in this respect. The difference between an acidity of 16.14, after being one day in transit, and an acidity of 30.88, after being two days in transit, is simply the result of time in developing the acid. During the first twenty-four hours but little develops, but during the next twenty-four hours the acid increases very fast.

The average for the cream shipped on August 26, 27, and 28, given under Table V, is interesting. An acidity of 9.93 at the station advanced only to 10.49 at the factory twenty-four hours later, with scores of 96 at the station and 93.08 at the factory. These lots were similar to those of preceding days, with the exception that the cans used in shipping were washed out with very strong lye water after the regular washing was given them and then rinsed with cold water before filling. The cans in the previous lots were washed with a common washing compound, and the work was not very well done. It will be noticed that the cream was much more uniform on arrival at the factory than any of that shipped on preceding days. This subject of can washing will be referred to again.

A reference to Table IV shows the same general results as those just mentioned. The pasteurized cream, whether sweet or sour, if not over thirty-four hours on the road, arrived at the factory in about the

same condition as regards acidity as when it left the station. It will also be seen that there is a limit to the formation of acid. Cans Nos. 1 to 15 in Table IV show cream shipped, some sweet and some sour, and the acidity on arrival, seventy-two hours later, is about the same for all, an average degree of acidity of about 34.

THE KEEPING QUALITY OF RAW CREAM SHIPPED.

Table VII shows that raw sour cream, with an acidity of 21 when shipped, on arrival at destination, twenty-four hours later, had increased to 33.8, or an increase of 12.8. The average score at the station was 93.96, while at the factory it was 89.96. Contrasting this with cream that was two days in transit, as shown in Table VIII, the difference is not found very marked, at least not so much so as in the case of the pasteurized cream. This cream started under conditions practically equal to those for cream one day on the road, the degree of acidity at the station being 26.5, and when it arrived at the factory, forty-eight hours later, it had increased 12, or to 38.5, showing about the same increase as that which was one day on the road. The average score on this cream was 92.02 at the station and 86.88 at the factory. This cream was shipped in refrigerator cars under exactly the same conditions as the pasteurized cream; in fact it was shipped along with the latter.

The average of cream shipped on August 29 and 31 is here as interesting as in the case of pasteurized cream. (See Table V.) This cream left the station with an average degree of acidity of 14, and arrived at the factory twenty-four hours later with an acidity of 31.1, the average score falling from 94.72 to 89.68. The same precautions in regard to cans were used in this case as on August 26, 27, and 28, as noted under "Pasteurized cream." For greater convenience in making comparisons, the following table is arranged to show the averages from Tables IV, V, VI, VII, and VIII:

TABLE IX.—Averages of data relating to cream shipped on July 27, as shown in Table IV, and of all data shown in Tables V-VIII on cream shipped from Colby to Topeka, Kans.

No. of table.	State of cream.	Time on road.	Butter fat.	Station acidity.	Factory acidity.	Station grade.	Factory grade.	Fall in grade.
		<i>Hours.</i>	<i>Per cent.</i>					
IV.....	Pasteurized.....	34		24.10	25.60	88.52	88.88	0.36
IV.....	Raw.....	34		25.00	39.30	91.00	88.16	2.84
V.....	Pasteurized.....	24	35.33	10.21	16.14	95.97	91.96	4.01
V.....	Pasteurized.....	24	36.10	9.93	10.49	96.00	93.08	2.92
VI.....	Pasteurized.....	48	34.40	12.28	30.88	95.16	88.76	6.40
VII.....	Raw.....	24	35.01	21.00	33.80	93.96	89.96	4.00
VII.....	Raw.....	24	34.74	14.00	31.10	94.72	89.68	5.04
VIII.....	Raw.....	48	35.27	26.50	38.50	92.02	86.88	5.14

a Rise.

In Table IX are first introduced for comparison averages of the data from Table IV, relating to cream shipped on July 27. On that date it was so arranged that every other can, as it ran from the receiving vat, should be pasteurized and the others should be shipped raw. This gave a direct comparison between raw and pasteurized sour cream where the cream was identical and all conditions alike except that of pasteurization. Unfortunately this is the only comparison of this kind from all the data given, but the example is a good one and is interesting. It will be seen that the eight cans that were pasteurized at the station scored there 88.52, as recorded in Table IV, while the same number of cans of unpasteurized cream scored 91. This difference was due to a peculiarly bitter or astringent flavor in the pasteurized sour cream that caused it to be scored down. This evidently did not show at the factory, as no comment was made there in regard to it, although it was looked for. It is interesting to note that the unpasteurized sour cream was scored on arrival at the station nearly as high as the pasteurized sour cream.

PASTEURIZING CREAM—GENERAL CONSIDERATIONS.

Does it pay to pasteurize sour cream at the station? A careful study of Table IX would indicate that it does not. The question as to whether it would pay to equip a station with a complete pasteurizing outfit for the purpose of pasteurizing sweet cream alone is an open one. It will depend largely on the amount of sweet cream the station will furnish and how well the work can be done at the station. The cost of pasteurizing must be taken into account and compared with the benefits derived. If the cost of equipping and maintaining a series of stations with pasteurizers is going to be greater than the sum derived from the advance in price of butter because of pasteurizing, it certainly will not pay. The data given in the tables, while very incomplete in many of the things that ought to be definitely known, may be a guide to some creamery company that wishes to experiment further along these lines. If so, it will be the greatest service to which they can be put.

There are a few things that the man operating a pasteurizing station must observe if he wants success in getting and keeping the quality of his product. Pasteurizing is performed for the purpose of destroying the germ life that the cream contains. This is done by heat. The heat is applied either by steam directly from the boiler or by exhaust steam from the engine, or it may be by the steam that runs the pasteurizer, as in turbine machines. In the continuous pasteurizers in use the temperature of the cream as it leaves the machine is usually between 160° and 190°. The higher the temperature the more thorough the work, for the more complete is the destruction of the germ life. Not all germ life is destroyed by pasteurizing. "Sterilizing" means the

complete destruction of all the germ life, but this is impracticable outside of a laboratory well equipped for doing such work. The success of pasteurization depends upon the following things: (1) Sufficient heat to destroy the greater portion of the germ life; (2) quick cooling, which also aids in the destruction of germ life or causes those germs not destroyed to lie in a dormant condition, and (3) thorough cleanliness of everything that comes in contact with the cream. The work is often rendered useless because the cream is again inoculated with the germs from a dirty can, a stirring rod, or a thermometer taken from cream not pasteurized and put into the pasteurized cream. Insufficient after-cooling of cream will also render pasteurization useless. One thing that must be observed; or the work will be a failure, is that everything which comes in contact with the cream after it is pasteurized must be clean.

In the experiments conducted at Colby one of the hardest things to overcome was the foul smell in the shipping cans. All ordinary means of washing seemed to fail in eradicating these odors, and cream from the same lot placed in different cans at the station would reach the factory in various stages of fermentation and presenting a variety of odors. It was not until the cans were rendered practically sterile by washing in strong concentrated-lye water that the difficulty was overcome. For the best results in pasteurizing, the cream should be delivered by the farmer in a perfectly sweet condition. The Western creameries have to some extent adopted methods to help along in this line.

VII. CREAM GRADING.

This is a subject that is new to the Western creamery man—too new for any results of actual practice to be given. The author of this bulletin recently recommended a system for grading cream at the stations, which has been adopted by one creamery company and will probably be adopted by many others in its entirety or in a modified form. The question of grading and buying on grade has been agitated for a long time, but there seemed to be obstacles in the way that had to be overcome. The right or wrong of the matter was never disputed. The lack of machinery for putting it into force and the difficulty of getting any concerted action on the part of the creameries stood in the way. It was thought by many that such a system would mean a lowering of the price from 1 to 2 cents a pound to the farmer and that he would look at it in that light and resent the move. A careful study of the situation and conversation with many farmers in different parts of the country showed that they, too, recognized the right and the necessity for a system which would put a premium on good cream rather than on bad cream.

The investigation of patrons' cream at Colby, as recorded in Table I, showed several possibilities not before taken into account. In the first place there are a few who can already furnish sweet cream from three to four times per week. Then there are a few who can deliver every day, and a much larger number who can at least furnish part of their cream sweet if told how. Patrons of this class come in three or four times a week, bringing all their cream in one can, all sour, and only fit for second grade. As previously stated, it may be impossible for these men to come any oftener. The case of a few of them furnishes a clew to a partial solution of the difficulty. It will be noticed that a few did not mix all their cream together, but brought it in two cans—one sour and one sweet. There might be four milkings in one and two in the other, or two milkings in each lot, so that one-third or one-half of their delivery would be sweet cream. It was also found that men delivering their cream in small cans usually had the best cream. Two gallons in a 10-gallon can might be sour, while the chances were much greater of its being sweet if delivered in a 3-gallon can. After careful study it was estimated that if all the farmers would keep their last two milkings separate and use small cans, fully half of the cream would be delivered to the creamery perfectly sweet. This simply means that if the farmer would expend a dollar or two for two or three more cans he could get the best prices for half of his cream, and would then have to take from 1 to 2 cents less for the other half. With this 1 or 2 cents difference acting as an inducement to improve along these lines, as suggested in the first part of this bulletin, he would soon be bringing three-fourths of all of his cream sweet. The coming year will, no doubt, demonstrate the advantage of this practice.

It is not thought that this change can be made all at once, but it will have to be a matter of growth on the part of those in the business. The thought of grading cream at once called for a dividing line. As has been observed the acidity of the cream has in the greater number of cases indicated its value quite closely, so closely in fact that it was thought feasible to do the grading on the basis of acidity. It was recommended to the creamery company already mentioned that it draw the dividing line at 15 by Mann's acid test, and that the station operator be supplied with an alkaline tablet, the strength of which would just neutralize an acidity of 5.25 in 17.5 c. c. of cream measured into a cup with the pipette. This recommendation has been adopted by the company, and on the 1st of January, 1904, their station operators began grading on that system. It is thought that after a little practice the test will not be needed except in case of dispute between the operator and patron as to the condition of the cream. The company makes a difference of 1 cent per pound between the two grades.

The following directions are quoted from a circular sent out by the company to its station operators for making the alkaline test:

Preparing test solution.—Place in a perfectly clean one-half pint sample jar one perfect tablet and with a milk pipette measure into the jar 17.6 c. c. of pure water, temperature between 40° and 120° F. Close the lid on the jar and allow the tablet to completely disappear in the solution. When entirely dissolved, with the exception of a few particles of inert material that may be seen, the solution is ready for use. Measure out in a pipette from the cream to be tested exactly 17.6 c. c. and run it into the tablet solution. Rinse all cream from the pipette by drawing the mixture already in the sample jar into the pipette and allowing the mixture to again flow into the jar. If, after mixing, the color remains pink, the cream is sweet enough to grade No. 1, but should the pink color disappear and the mixture become the color of the cream, the cream sample is sour and grades No. 2.

How to know the color.—Should any trouble be experienced in determining whether or not any color is present in the test (this will occur only when the acidity of the cream is very near the line between sweet and sour), it is advisable to take another sample jar, place in it 17.6 c. c. of cream, the same as is being tested, with 17.6 c. c. of water, but no tablet. Place the two jars side by side on a piece of plain white paper. Compare the two by looking down through the mouths of the sample jars toward the white paper underneath. By this method any pink color may be seen if present in the sample containing the tablet.

In no instance try to examine the color of a sample by looking through the side, but always through the mouth of a jar. Examine tests in good bright light, but not in direct sunlight.

Sample jars.—The operator should be provided with as many sample jars as daily tests are required. The jars should be thoroughly washed and rinsed before using, and great precaution should be taken to keep them free from acid, lye, or sal soda. The lids should be closed while the tablet is in the solution before using, thus preventing any material from falling into the jars.

Water.—The water for dissolving the tablets should be as pure as it is possible to obtain. Endeavor to secure enough condensed steam for this water supply. If water from condensed steam can not be had, then use clean rain water or melted ice.

Should it be necessary to use water from a well or spring, the water should in every instance be boiled. The water supply for use in this test should be kept in a clean, tightly corked bottle or sealed glass fruit jar. Do not use water from a jug having contained at any time sulphuric acid or vinegar.

Pipette.—The ordinary 17.6 c. c. milk pipette is used for measuring the sample of cream for the test, also for measuring the water in which the tablets are dissolved. The pipette, like the sample jar, should be clean and free from any acid, lye, or sal soda.

Tablets.—The tablets should be kept dry and in a tightly covered box, away from any excessive moisture, and out of direct sunlight. Use for the test only perfect tablets. Use no broken tablets. Pay no attention to the color of the tablets other than that they give a cherry-red color when dissolved in 17.6 c. c. of water.

Suggestions for conducting the daily tests.—On arriving at the station, or as soon after as possible in the morning, take as many sample jars as tests will be required during the day, place in each one tablet and 17.6 c. c. of water, and close the cover. This will require only a short time and the tablets will be dissolving and will be ready for making the tests when the cream arrives. Proceed with the tests according to instructions already given. Should more tablets be dissolved than are needed, throw away the solution; do not attempt to keep it for use the next day.

Summary.—For each test dissolve one perfect tablet in 17.6 c. c. of pure water. Take a 17.6 c. c. sample of cream to be tested. If, when the cream is mixed with the tablet solution, the pink color remains, the cream is sweet enough to grade No. 1. If the color disappears, the cream is sour and grades No. 2. Keep everything in connection with the test free from acid, lye, or sal soda. Keep the tablets in a dry place.

The tablets used for this test are made in the chemical laboratory of the company sending out the foregoing directions. They are not as yet on the market. If the test proves a success in the operations of this company, the various supply houses will undoubtedly put tablets on sale.

It is not thought that this will cure all of the ills of the creamery business, but it will go a long way toward establishing a grade or line of demarcation between good and bad cream. It is, perhaps, only the first step of what should ultimately be considered the right thing in grading cream. If creamery men and patrons alike will look upon this as a means to an end—namely, that of improving the quality of cream from farm separators until the greater part of the cream delivered will make high-grade butter—this scheme of grading and the work leading up to it will not have been in vain. The author has no fear of the ultimate outcome of the farm-separator system if all who are concerned in it make the best use of the means they have at hand and study to know more about the business and to make a high quality of both cream and butter—the end to which all efforts should be bent.

VIII. SUMMARY.

The keynote of this bulletin is the one word *quality*. The introduction and opening discussion give a brief history of dairy progress in the West and some of the reasons why the farm separator is a necessity on the Western farm. In the second division the farm separator, its care and management, are discussed. This deals with the factors influencing separation, including speed of machine, temperature of milk, quantity of milk flowing through the bowl, the cream screw, and the factors of change in season, period of lactation, and richness of milk. The sanitary condition of the separator is specially emphasized. It must be kept absolutely clean. To insure this it must be washed after every separation. A good brush should be used for washing. Discard the dishcloth and dish towel.

Under "Management of cream on the farm" the first essential mentioned is clean milking. The dirt and dust adhering to the cow's udder should be wiped off with a damp cloth before beginning milking. In separating the milk should be poured directly into the supply can of the separator without the intervention of any strainer and while it still contains its animal heat. The cream should be caught in deep narrow cans for cooling. The farmer should be provided with a thermometer and some instrument for stirring the cream. Immediately

after separation the cream should be cooled to the temperature of the water direct from the well. For holding the cream the farmer should be supplied with a tank and windmill. All water pumped should be run through this cooling tank. The tank should be placed in a good milk house. This milk house should be kept free from everything except the milk and the utensils for handling it. Never mix warm cream with cold, as it is always sure to cause quick souring. In delivering the cream to the station or creamery it should be covered with a wet blanket in summer to prevent heating and a dry blanket in winter to prevent freezing. The frequency of delivery depends largely on the distance from the station and the ability of the patron to keep his cream sweet. Although it is believed that with proper care on the farm the cream can be delivered from thirty-two to seventy-two hours old in a sweet condition, the general rule should be to deliver it just as soon as possible after thorough cooling.

Experiments carried on at Colby, Kans., are next dealt with. The data here given and the deductions drawn from them sustain the statements and recommendations before set forth.

The question is then taken up from the creamery man's standpoint. The uncleanness of stations is no more to be excused on the part of the creamery man than is a dirty separator on the part of the farmer. Creamery men need to look well to this point. The methods of receiving cream are discussed under four general heads. The advisability of equipping a series of stations with pasteurizing outfits is doubtful unless large quantities of sweet cream can be secured. This conclusion may be disproved on further investigation, but deductions made from the work done at Colby are unfavorable to pasteurization at the stations. In shipping cream without pasteurizing the same precautions as to cleanliness and grading of cream should be observed as in the pasteurizing station. Means should be provided to secure hot water or steam in abundance. The handling of cream through a store is to be discouraged on every hand. It begets the same conditions that prevail in the handling of country butter. The direct shipper is at a great disadvantage so far as quality is concerned. In opening new territory direct shipping may be admissible, but as soon as twenty or more patrons are secured a receiving station should be established. The transportation of cream is still in a very backward state. Poor cars for the purpose are used and only the large companies have this service. With the development of the business the railroads will undoubtedly furnish better facilities for transportation.

An account is given of the experimental work in the shipment of cream from Colby to Topeka, Kans., covering shipments of sweet and sour cream, both pasteurized and raw, and the results are given in tabular form. One important deduction from this work is that it does not pay to pasteurize sour cream at the shipping station.

In conclusion the system of cream grading is dealt with. It is a system recommended by the author and adopted by a prominent creamery company. The observations and experiences of extended travel over the Western dairy territory and the investigations made at Colby, Kans., indicate that this scheme is entirely feasible. The result of its workings can not now be given, as it has been in operation only since January 1, 1904. It is based on the fact that an acid test gives a very fair indication of the quality of the cream. The dividing line between the grades 1 and 2 is made at 15 c. c. by Mann's test. The instructions given for making the test are taken bodily from a pamphlet issued by the above-mentioned company to their station operators.

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(Continued from second page of cover.)

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF ANIMAL INDUSTRY—BULLETIN No. 60.

D. E. SALMON, D. V. M., Chief of Bureau.

MANSON'S EYE WORM OF CHICKENS

(*Oxyspirura Mansoni*),

WITH A GENERAL REVIEW OF NEMATODES PARASITIC
IN THE EYES OF BIRDS,

AND

NOTES ON THE SPINY-SUCKERED TAPEWORMS OF CHICKENS

(*Davainea echinobothrida* (= *Tænia botrioplites*) and *D. tetragona*).

BY

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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., July 25, 1904.

SIR: I have the honor to submit herewith for publication the manuscript of two articles entitled, respectively, "Manson's eye worm of chickens (*Oxyspirura Mansoni*), with a general review of nematodes parasitic in the eyes of birds," and "Notes on the spiny-suckered tape-worms of chickens, *Davainea echinobothrida* (= *Tænia botrioplites*) and *D. tetragona*," by B. H. Ransom, B. Sc., A. M., scientific assistant in charge of the Zoological Laboratory of this Bureau.

The first-named paper is in two parts. The first part comprises a complete account of a parasitic nematode, the presence of which in North America has not previously been recorded. This parasite is found beneath the nictitating membrane of the eyes of chickens and peafowl, and chickens thus affected frequently exhibit a severe ophthalmia, which, if left untreated, ends in the loss of the eyes and may even lead to fatal results. The second part contains a complete summary of all the parasites allied to *Oxyspirura Mansoni* which occur in the eyes of birds.

The second article consists in a discussion of two important tape-worms of chickens. These worms, although distinctly different species, show such close anatomical similarities that they have hitherto been much confused, and indeed their specific identity seems so far never to have been clearly and precisely recognized. One of them (*Davainea echinobothrida* = *Tænia botrioplites*) is the form which frequently produces the nodular disease of the intestines, first reported for this country in 1895 by Dr. Veranus A. Moore, at that time pathologist in this Bureau; while the other (*Davainea tetragona*) produces no apparent lesions.

The economic importance of recognizing and distinguishing between the two species is evident. Upon the basis of the specific diagnoses given in this paper, the worms may be readily identified and separated from each other, the characteristic differences between the two forms being here given for the first time.

The illustrative work necessary for the articles has been done by W. S. D. Haines, the artist of this Bureau.

Very respectfully,

D. E. SALMON,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary.

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MANSON'S EYE WORM OF CHICKENS (OXYSPIRURA MANSONI),

WITH A GENERAL REVIEW OF NEMATODES PARASITIC
IN THE EYES OF BIRDS.

By B. H. RANSOM, B. Sc., A. M.,

Scientific Assistant in Charge of Zoological Laboratory, Bureau of Animal Industry.

MANSON'S EYE WORM (OXYSPIRURA MANSONI) OF CHICKENS.

INTRODUCTION.

The attention of the Bureau of Animal Industry has recently been called to the occurrence of a parasite in the United States which has hitherto not been published for this country. The parasite in question is a round worm known as *Oxyspirura Mansoni* (= *Filaria Mansoni* = *Spiroptera Emmerezii*) and is found beneath the nictitating membrane of the eye of chickens. The worms of this species are white, small, and thread-like, measuring a little over half an inch in length, with the thickness of a fine sewing needle. The body is thickest near the middle and tapers gradually toward each end. The posterior end is the more pointed, and in the male is more or less curved ventrally, while in the female it is straight. The females are generally slightly larger than the males. The number which may be present in a subject varies from few to many; Mr. H. C. Niles, of Summerland Key, Keywest, Fla., states that he has taken nearly 200 from the eyes of a single chicken.



FIG. 1.—Manson's eye worm (*Oxyspirura Mansoni*). Male on the left and female on the right. Natural size. Original.

SYMPTOMS.

The presence of these worms in the eye is frequently borne by chickens without any apparent inconvenience. For example, the chicken mentioned above was said to be perfectly healthy and entirely without symptoms. On the other hand, it seems that considerable irritation of the ocular membranes would be produced by the movements of the worms, which are seen to be very active when the nictitating membrane is drawn away from the cornea so as to expose them to view. Apart

from the possibility of an actively irritating influence, the worms undoubtedly have an injurious effect merely from their presence as foreign bodies. It would appear in any case that the presence of these parasites in a locality so sensitive would tend to establish an inflammation, and at least be a condition predisposing to inflammation from other causes.

While the presence of the parasites, as already mentioned, is commonly borne without seeming inconvenience, such is not always the case. Distinct symptoms of irritation become evident at times. Emmerez (Emmerez & Mégnin, 1901a) observed that an affected bird shows signs of uneasiness and scratches at its eyes, which exhibit an acute inflammation accompanied by an abundant secretion of tears. The first stages of the inflammation seem to be confined almost entirely to the eye itself. The nictitating membrane, which is swollen and projects slightly beyond the eyelids at the corner of the eye, is kept in continual motion to and fro, as if to remove some foreign body. The eyelids become stuck together and a white cheesy matter, easily removed, gathers beneath them.

Further symptoms appear which seem to be due to a complication with catarrh. The tissues surrounding the eye and the infra-ocular sinuses become highly inflamed, and are reddened and swollen. (See Frontispiece.) The eyeball is likely to be involved; the cornea becomes opaque, and later the entire eyeball is destroyed and the orbital cavity is filled with a yellow purulent material. When this stage is reached the worms are no longer to be found in the eye. The nostrils may also be affected and become obstructed in the catarrhal process, and finally fatal results may follow. The bird becomes somnolent, scarcely eats, declines in strength, becomes anemic, and dies in three or four weeks.

TREATMENT.

The treatment consists in the removal of the worms, combined with the treatment of the associated catarrh. The worms may be removed either by direct mechanical means, as with small forceps, which operation is more or less dangerous and painful to the fowl, or by irrigating with a solution of bicarbonate of soda or a 1 or 2 per cent solution of creolin. The irrigation has the effect of partially dislodging the worms, which may then be removed entirely by wiping away with a soft cloth.

Further treatment is directed toward alleviation of the inflammation or the cure of the catarrh which may have been established. Irrigation of the eyes with a mildly antiseptic solution, such as a 4 per cent boric acid solution or 1 per cent creolin solution, is indicated, together with irrigation, also, of the nose and mouth if the nostrils are affected. Anointing the eyes with a mixture of lard 9 parts and iodoform 1 part.

or with carbolized vaseline, is likely to give good results in some cases. The general sanitary conditions should also be attended to and stimulating food furnished as in the treatment of simple catarrh.

Prophylaxis.—No special prophylaxis is evident, as the life history of the parasites is so far unknown (see p. 18). Certain general precautions which are likely to prevent the spread of this as well as of other parasitic diseases should, however, be taken. Affected fowls should be isolated. The chicken houses should be kept clean and disinfected frequently by the use of boiling water and whitewash, with which carbohc acid, creolin, or other disinfectant has been mixed. The yards likewise should be kept clean and free from excessive moisture. Chickens should not be allowed to drink from stagnant pools, but pure drinking water should be furnished in vessels which can be frequently cleaned.

HISTORICAL REVIEW.

We find this species first referred to by Cobbold (1879b, p. 440) in the following words:

Here I may mention that on the 10th of April, 1878, I received a letter from Doctor Manson, of Amoy, announcing his acquaintance with a filaria infesting the eye of the fowl. On the 9th of May I also received from Doctor Manson the head of a bird showing examples of the worm. As the species is new to science I have proposed to call it *Filaria Mansoni*, after the discoverer. The male is five-eighths inch and the female three-fourths inch in length.

Magalhães (1888) was the next observer to encounter this worm, which he described from specimens collected in Brazil, five from the eye of a fowl and two from the eye of a peacock.

Seven years later (1895) he published a French translation of his original Portuguese paper. In his later paper he was able to change to a positive statement his earlier expressed belief as to the identity of the Brazilian form with *Filaria Mansoni*, having had in the meantime opportunity to study specimens collected by Manson in China.

Emmerez & Mégnin (1901a) noticed a peculiar ophthalmia among chickens on the island of Mauritius. Following the account which they have given, the disease is very contagious and frequently ends in death. It begins as an ordinary ophthalmia. The bird affected appears uneasy and scratches at its eyes, which become much inflamed and watery. The eyelids stick together and a white, cheesy matter, easily removed, gathers beneath them. At other times there is a complication of nasal catarrh, together with great inflammation and edema of the infra-ocular sinuses. In such cases the condition of the bird may be considered very serious. With its eyes almost always closed it remains in one place, eats but little and with difficulty, becomes anemic, and dies in twenty to thirty days.

One of the fowls which had begun to show symptoms of the disease was isolated, and Doctor Emmerez observed the following:

The trouble seemed to be confined to the eye itself, while the eyelids exhibited no inflammation, except that the nictitating membrane was slightly swollen and projected at the corner of the eye. It was drawn rapidly and constantly across the eye, as if to remove some foreign body. When the membrane was lifted a large number of little white slender worms in active motion were seen beneath. Doctor Emmerez was able to remove them all, to the number of about 50.

Treatment becomes very simple after the discovery of the worms. A solution of bicarbonate of soda is dropped in the eye several times a day. Under the influence of this treatment the worms come out from under the membrane, fall between and under the eyelids, and are carried outward with the tears. A fine cloth should be used to finally remove them, as they very quickly regain their position under the membrane. As an alternative, one may remove the worms with fine forceps and complete the treatment by bathing the eye with a warm 4 per cent solution of boric acid.

Taken at the start this affection offers nothing serious, but if allowed to become complicated with nasal catarrh it may prove fatal.

In addition to the above account Mégnin gives a short zoological description with figures and proposes to name the worm *Spiroptera Emmerezii*, believing it to be a new species, but the description leaves no doubt as to its identity with the previously described *Filaria Mansoni*.

In 1901 and 1902 Mr. F. C. Clark collected numerous specimens at Laughlands, Jamaica, which are preserved in the helminthological collection (Nos. 3182 and 3257) of the Bureau of Animal Industry, Department of Agriculture. The Bureau is under obligations to Mr. H. C. Niles, Keywest, Fla., for supplying a number of chickens infected with this parasite.

Attention may here be called to the fact that so far the worm has been reported only from localities on or near the seacoast. This point may prove to be of significance in the life history or it may be only a coincidence, but in any case it is worthy of remark.

ANATOMY.

EXTERNAL APPEARANCE.

The worms are white, with the customary slender threadlike form of the nematodes, and are attenuated at both ends. The attenuation is greater toward the posterior end, which is pointed, while the anterior end is rounded (fig. 1).

Males may be distinguished from females by their generally smaller size, and by the tail, which is curved ventrally (fig. 1).

The cuticula is very transparent and perfectly smooth. Magalhães (1888, 1895) describes the cuticula as finely striated transversely, but Mégnin (Emmerez & Mégnin, 1901a) remarks that there is no visible

striation of the cuticula, nor have I seen such markings in any of a large number of specimens examined.

The muscle fibers of the body wall are plainly visible through the cuticula, under low magnification, as coarse longitudinal striations, and in favorable specimens much of the internal anatomy is also apparent.

On each side of the body 350 to 400 μ from the anterior end is a very small rounded cervical papilla, scarcely discernible, provided with a short projecting hair-like process, evidently a sense organ. A pair of very small conical papillæ, each with a tiny opening, is situated near the tip of the tail in both sexes (fig. 4.)

The mouth (fig. 2, *m.*) is circular or oval, and is surrounded by a chitinous ring (figs. 2, 3, *c. o. r.*) divided into six lobes by narrow clefts extending inward from the outer edge. These clefts correspond to the

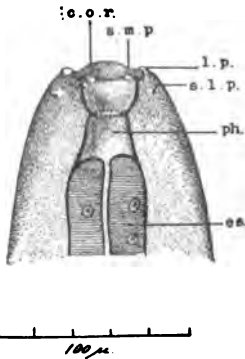


FIG. 3.—Manson's eye worm (*Oxyuris Mansoni*). Dorsal view of head: *c. o. r.*, circumoral cuticular ring; *es.*, esophagus; *l. p.*, lateral papilla; *ph.*, pharynx; *s. l. p.*, sublateral papilla; *s. m. p.*, submedian papilla. Enlarged. Original.

lateral and submedian longitudinal lines. Projecting from the surface of the head near the outer edge of the ring and in relation with the clefts are six small papillæ (figs. 2, 3, *l. p.*, *s. m. p.*) to be distinguished only with difficulty and usually only when the head is viewed *en face* under a high power. On the sides of the head, posterior of the circle of papillæ just referred to, are four papillæ (figs. 2, 3, *s. l. p.*) which from their position may be designated sublateral papillæ, as they are located midway between the lateral and submedian lines. The sublateral papillæ measure 4 to 6 μ in length, and are slender and conical in shape. They project outward almost at right angles to the surface, and under a moderately high power are readily apparent in a lateral view of the head.

The excretory pore (fig. 5, *ex. p.*) is situated in the ventral line at about the level of the cervical papillæ; that is, 350 to 400 μ from the anterior end of the body.

Male: Cobbold (1879b) gives the length of the male as five-eighths of an inch (about 16 mm.); Magalhães (1888, 1895), 14 mm.; and Ménégnin (Emmerez & Ménégnin, 1901a), 12 mm. The maximum length of the speci-

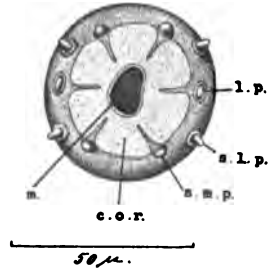


FIG. 2.—Manson's eye worm (*Oxyuris Mansoni*). Anterior view of head: *c. o. r.*, circumoral cuticular ring; *l. p.*, lateral papilla; *m.*, mouth; *s. l. p.*, sublateral papilla; *s. m. p.*, submedian papilla. Enlarged. Original.

mens which I have measured was 14 mm., the minimum 10 mm. Specimens of the latter length were clearly immature; 12 to 13 mm. was the usual size of mature worms. The diameter of the body is $50\ \mu$ at the anterior end, 200 to $350\ \mu$ at the middle, and 65 to $150\ \mu$ at the opening of the cloaca, which is situated 320 to $400\ \mu$ from the tip of the tail. As already mentioned, the tail is more or less curved ventrally and may describe one complete revolution of a spiral, or less. There are six pairs of genital papillæ (fig. 4) in the immediate neighborhood of the anal opening—two pairs postanal and four pairs preanal. Mégnin (Emmerez & Mégnin, 1901a) mentions but five pairs of papillæ; Magalhães (1888, 1895), on the other hand, states that there are eight pairs—three postanal and five preanal. In the considerable number of specimens which I have examined there were in no case more nor less than six pairs of genital papillæ.



FIG. 4.—Manson's eye worm (*Oxyurura Mansonii*). Ventral view of posterior end of male, showing papillæ. Enlarged. Original.

The papillæ (fig. 4) of the first and second pair are situated a short distance on either side of the median line. The second pair is just posterior of the anus, and the first pair about $50\ \mu$ behind the second. The papillæ of the third pair, adanal rather than preanal, are almost on a line with the anal opening, and are so far distant from the median line as to be sublateral in position. The fourth pair is 30 to $40\ \mu$, the fifth pair 60 to $70\ \mu$, and the sixth pair 100 to $130\ \mu$, anterior of the anus. Of any two successive pairs, the fourth and fifth pairs are generally the nearest together, while the fifth and sixth are the farthest apart (the lateral distance which separates the papillæ of the third pair from the others not considered). Passing forward from the first pair of papillæ, which are the closest together, and

leaving out of consideration the third pair, the lateral distance between the papillæ of each pair gradually increases, reaching a maximum in the sixth pair, which are situated nearly on the submedian lines. The papillæ of the sixth, fifth, fourth, second, and first pairs are thus located on two converging lines which meet a short distance posterior of the anus. There is more or less asymmetry in the arrangement of the papillæ, so that the papillæ of any one pair are not always exactly opposite. Owing to this circumstance it is sometimes difficult, from a lateral view alone, to determine the exact number of papillæ and their arrangement into pairs. The spicules (fig. 6, *sp.*) are often seen extruding from the anal

opening. One of the spicules is long and slender, and the extruded portion may measure 1 mm. or more in length, while the other is short and thick and is only slightly protrusible. In no specimen examined was there any evidence of lateral cuticular membranes in relation with the tail, as described by Mégnin (Emmerez & Mégnin, 1901a).

Female: The females measure from 12 to 18 mm. in length, 50μ in diameter at the anterior end, 400 to 430 μ at the middle of the body, 210 to 280 μ at the vulva, and 90 to 100 μ at the anus. The vulva (fig. 7, *vul.*) is in the posterior part of the body, 1 to 1.4 mm. from the tip of the tail. It is an almost circular opening 40 or 50 μ in diameter, surrounded by a very prominent raised border. The anus (fig. 7) is situated 400 to 530 μ from the tip of the tail, and its location is frequently indicated by a small papilla-like swelling of the cuticula. Magalhães (1888, 1895) gives the following table of measurements of five females:

Measurements of Manson's eye worm (female).

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
	mm.	mm.	mm.	mm.	mm.
Length	15.00	15.00	16.00	17.00	18.00
Diameter at anterior end.....	.04	.04	.04	.05	.05
Diameter a little farther back.....	.09	.08	.08	.07	.07
Diameter at middle third	.42	.41	.42	.41	.43
Diameter at level of vulva	.22	.22	.28	.28	.21
Diameter at level of anus	.10	.09	.10	.10	.10
Diameter at extremity of tail	.01	.01	.01	.02	.01
Diameter of mouth opening.....	.03	.03	.03	.03	.03
Diameter of esophagus	.05	.05	.05	.05	.05
Diameter of vulva.....	.06	.07	.06	.05	.05
Distance of vulva from tip of tail	1.00	1.20	1.20	1.20	1.33
Distance of anus from tip of tail	.40	.40	.40	.40	.53

INTERNAL ANATOMY.

An extensive account of the internal anatomy is deemed unnecessary for the purposes of this article, and accordingly no attempt has been made to elaborate the finer anatomical and histological details. The following discussion is therefore confined to the more general relations of internal structure.

NERVOUS SYSTEM.

A nerve ring (fig. 5, *n. r.*) surrounds the esophagus about 250 μ from the anterior end of the body. It is thus some distance anterior of the excretory pore.

In the immediate neighborhood of the nerve ring are a number of large cells with prominent nuclei, which, from their position, were interpreted by Magalhães as ganglion cells. Some of them are smaller than the rest and stand in direct relation with the fibers of the nerve

ring. The remainder are arranged in four groups, corresponding to dorsal, ventral, and lateral ganglia. The lateral groups are embedded

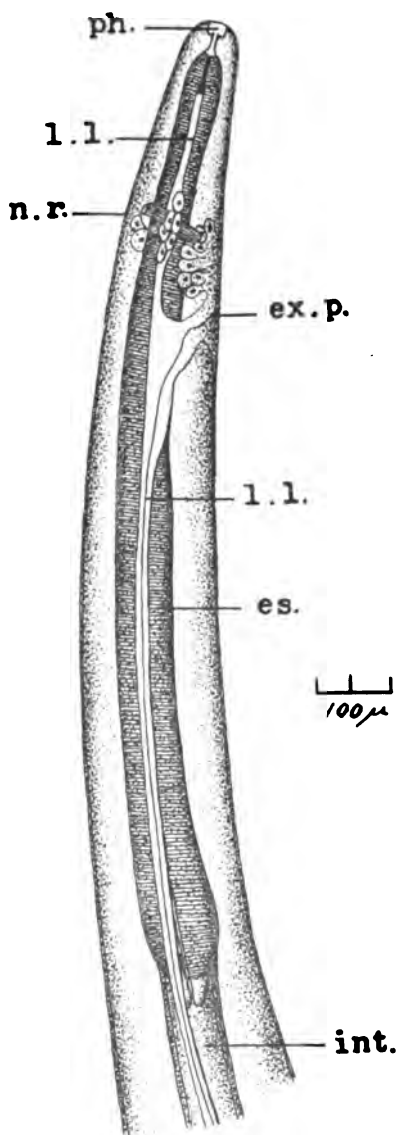


FIG. 5.—Manson's eye worm (*Oxyuris Mansonii*). Side view of anterior end of body: *es.*, esophagus; *ex. p.*, excretory pore; *int.*, intestine; *l.l.*, lateral line; *n. r.*, nerve ring; *ph.*, pharynx. Enlarged. Original.

in the substance of the lateral bands on each side of the nerve ring. The dorsal group is composed of four or five pyriform cells with processes extending to the body wall in the dorsal line. The ventral group is largest, and extends from the nerve ring to the excretory pore. In cross section it is triangular, with the apex of the triangle joining the body wall in the ventral line, while the base is closely applied to the ventral surface of the esophagus. Cells of similar appearance to the above occur in a group in each lateral band opposite the terminal portion of the intestine in both male and female.

The following nerves were seen: A prominent ventral and a small dorsal nerve extending backward from the nerve ring in the ventral and dorsal lines, respectively, and one or two nerves extending forward from the nerve ring in each lateral band. The ventral nerve divides into two a short distance posterior of the nerve ring, and the two portions, after passing one on either side of the common excretory canal, unite again on the median line.

EXCRETORY SYSTEM.

The lateral bands (fig. 5, *l. l.*) extend the length of the body, and measure 15 to 20 μ in width. They have the usual structure, contain numerous nuclei, and through them run the longitudinal

excretory canals, which unite posterior of the nerve ring, and open by the common tube thus formed at the excretory pore (fig. 5, *ex. p.*).

There appears to be a connection posteriorly between the excretory canals and the openings through the small papillæ (fig. 4), near the tip of the tail, already mentioned, but this relation could not be determined with certainty.

MUSCLE SYSTEM.

The muscles of the body wall have the well-known polymyarian arrangement.

A fan-like system of fibers (figs. 6, 7) is found in the tail of both male and female in relation with the terminal portion of the intestine. Beginning close together in the neighborhood of the anus, the fibers extend in divergent lines to attach to the dorsal wall of the body.

DIGESTIVE SYSTEM.

The circular or oval mouth (fig. 2, *m.*) opens into a chitinous mouth capsule, or pharynx (figs. 3, 5, *ph.*), in which two distinct portions may be defined, anterior and posterior, the former somewhat shorter and broader than the latter, and marked off from it by a prominent irregular ridge projecting forward on the inner surface. The pharynx is triangular in cross section. Its length is 40 to 60 μ . The anterior portion measures 15 to 25 μ in length by 25 to 30 μ in width; the posterior portion 25 to 30 μ in length by 20 to 25 μ in width.

The esophagus (figs. 3, 5, *es.*), which begins at the base of the pharynx, is a thick-walled muscular organ with a narrow triradiate lumen lined by cuticula, and belongs to the filariform type. It is club-shaped, gradually increasing in size toward the posterior end. The diameter of its anterior end is about 40 μ ; of its posterior end, 80 to 100 μ ; and the length is about 1.5 mm. The posterior end is rounded and slightly bulbous, and at the extremity, which projects into the lumen of the intestine, prolonged into a rounded conical tip, without muscular elements and apparently composed entirely of chitin.

Except for irregular dilations the intestine (figs. 5, 6, 7, *int.*) varies little in diameter during its almost straight course from esophagus to rectum and measures in that dimension from 50 to 100 μ . Its comparatively thin wall is composed of columnar cells about 8 μ in length, covered internally by the peculiar cuticular lining of the nematode intestine. The cells (fig. 7, *x.*) forming the wall of that portion of the intestine just in front of the rectum are larger and less closely crowded than elsewhere and the wall is thicker. In a ventral view of the female this region of the intestine is seen to be sharply marked off from the rectum by a straight transverse line.

The rectum (fig. 7, *rect.*) tapers gradually toward its opening at the anus. Its wall is compact and lined inwardly by a dense layer of cuticula. It measures 100 to 120 μ in length. The fan-like system of fibers extending from its terminal portion to the dorsal wall of the body has already been mentioned.

REPRODUCTIVE SYSTEM.

Male: The testis begins anterior of the middle of the body as a slender cord, which makes a number of short loops backward and forward and gradually increases in diameter. It may extend into the anterior part of the body almost to the nerve ring. From about the middle of the body, where it has attained a size of 50 to 60 μ , its farther course backward is almost a straight line. About 1.5 mm. in front of the anus there is a constriction which marks the beginning

of the terminal portion or ejaculatory duct (fig. 6, *det. ej.*). The wall of this portion is thick, composed of tall columnar cells, and the lumen is narrow. The portion immediately anterior of the constriction, with thin walls and wide lumen, serves as a seminal vesicle (fig. 6, *v. s.*). The ejaculatory duct becomes smaller near its terminus and joins the intestine on the ventral side of the latter, 80 to 100 μ from the anal opening, to form the cloaca.

The long spicule measures 3 to 3.5 mm. in length by 8 to 10 μ in diameter; the short spicule, 200 to 220 μ in length by 30 μ in maximum thickness. The spicules are hollow. There is no opening through their rounded distal ends, while their proximal ends are squarely cut off and open.

The short spicule may be

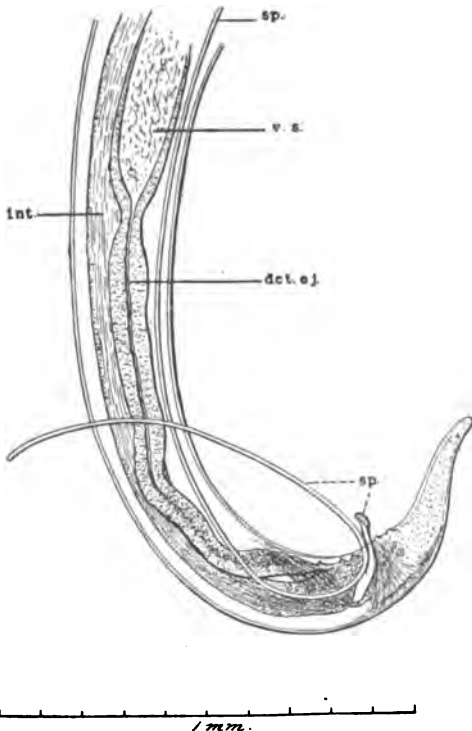


FIG. 6.—Manson's eye worm (*Oxyspirura Mansoni*). Lateral view of posterior end of male: *det. ej.*, ejaculatory duct; *int.*, intestine; *sp.*, spicules; *v. s.*, seminal vesicle. Enlarged. Original.

compared roughly to a boat. On its ventral surface it has a longitudinal depression or groove, which serves as a guide for the slender spicule. The delicate transverse striation of the spicules is not superficial but affects their entire thickness. The spicules are situated on opposite sides of the cloaca. If the long spicule is on the right side, the short spicule is on the left side, and vice versa, and this relation varies in different individuals. Each spicule is surrounded by a close-fitting sheath, which opens into the dorso-lateral side of the cloaca near its terminus. The walls of the spicule sheaths are well supplied with

longitudinal muscle fibers, and a strong bundle of muscle fibers (fig. 6) extends forward from the anterior end of each spicule attaching finally to the body wall near the ventral line.

Female: The female organs begin in the posterior portion of the worm as two slender tubes, the ovaries (fig. 7, *ov.*), which describe a number of loops in their course forward, and increasing gradually in size are transformed into two large uteri filled with eggs in various stages of development. Besides lesser loops each uterus describes a long loop, the two limbs of which extend nearly the entire length of the worm, so that in a cross section near the middle of the body each uterus is cut twice. The bend of the long loop of the uterus is in the anterior part of the body. The two uteri ultimately unite in the posterior

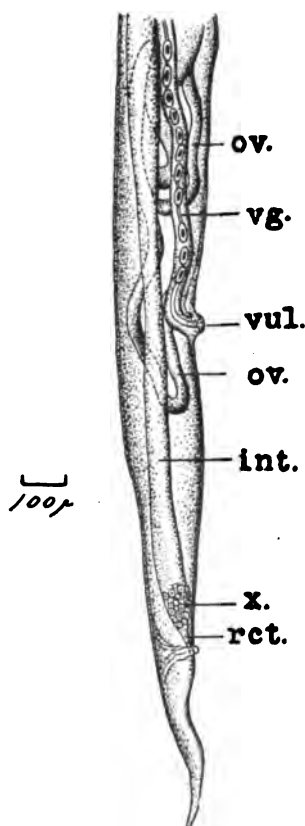


FIG. 7.—Manson's eye worm (*Oxyepirura Mansoni*). Lateral view of posterior end of female: *int.*, intestine; *ov.*, ovary; *rct.*, rectum; *vg.*, vagina; *vul.*, vulva; *x.*, cells surrounding rectum. Enlarged. Original.

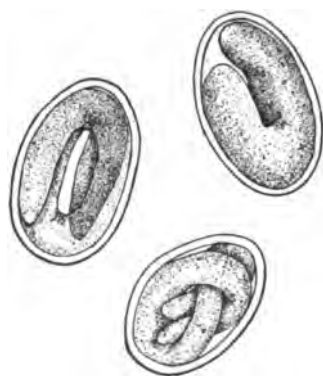


FIG. 8.—Manson's eye worm (*Oxyepirura Mansoni*). Eggs containing embryos. Enlarged. (Drawings by E. C. Stevenson.)

part of the body about 1.5 to 2 mm. in front of the vulva to form the vagina (fig. 7, *vg.*), which extends in a nearly straight course backward to the vulvar orifice. The vagina measures about $50\ \mu$ in diameter, the uteri about $100\ \mu$ in maximum diameter. The wall of the vagina increases in thickness posteriorly, due to the gradual accumulation of circular muscle fibers. The eggs are forced along the narrow lumen of the vagina in a single row, but in the uterus as many as 15 or 20 may be counted in a single cross section.

Segmentation of the eggs does not begin until after the formation of the shells. At this time the eggs are much elongated, with rather square ends, and measure 24 by $12\ \mu$. With progressing development the eggs increase in size and become more rounded, so that in the later stages, wherein the worm-like embryo is rolled up inside the shell, they are almost perfectly oval and measure 50 by 40 to 65 by $45\ \mu$ (fig. 8).

LIFE HISTORY AND DEVELOPMENT.

The life history has not been determined. Mégnin (Emmerez & Mégnin, 1901a) ventures the opinion that eggs are deposited outside the eye, since Emmerez never observed free eggs or embryos in the eye,

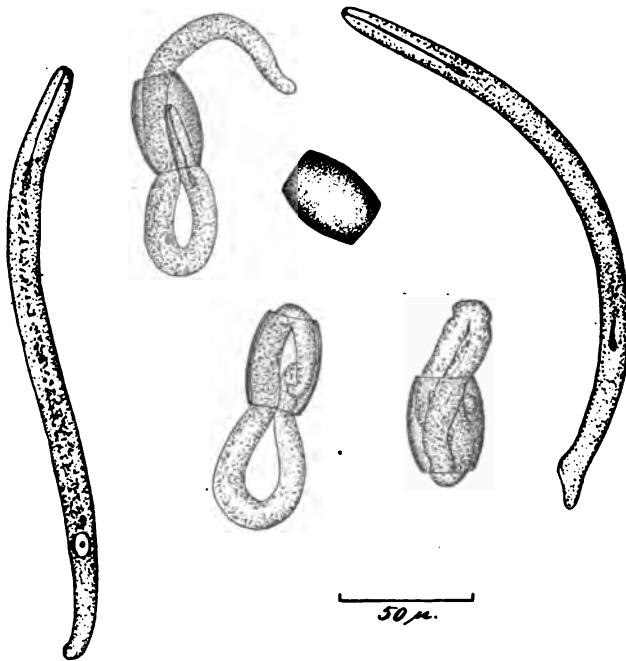


FIG. 9.—Manson's eye worm (*Oxyuris equi*). Embryos. Enlarged. Original.

and he surmises that development takes place in water. Experiments bearing upon the life history have been performed in this laboratory, but they have been almost barren of results.

On July 17, 1903, two female worms were removed from the eye of a chicken into salt solution, and on the following day were placed in water and torn into small pieces with needles, thus setting free a large number of eggs containing embryos. The embryos were kept at the temperature of the room. Two days later there was no apparent

change, but on the following day, July 21, many of the embryos had hatched.

In the hatching of the embryo (fig. 9) a small cap splits off from each pole of the egg, following a smooth even line of fracture, leaving the body of the eggshell in the form of a barrel without head or bottom. In many instances but one cap splits off. The newly hatched embryo is only slightly attenuated toward each end. The anterior end is rounded and the posterior end only very bluntly pointed. Little could be distinguished of the internal structure, which was still in a very incomplete condition of development. The cuticular lining of the filariform esophagus was distinctly evident, leading backward from a small cup-like cavity in the anterior end, indicating a rudimentary mouth capsule or pharynx. The embryos measure 225 to 250 μ long by 12 μ in maximum thickness; the esophagus has a length of about 50 μ .

The above-mentioned embryos were quiescent when they were first seen after hatching, and apparently dead, with the exception of one, which exhibited feeble movements, but it also became quiet in a short time. The embryos manifested no further signs of life and were entirely decomposed at the end of a few days.

A female worm from the same lot was also cut up on July 18 and the eggs contained were transferred to the eye of a healthy chicken. Two weeks later, August 1, the eye seemed to be slightly swollen and a small white opaque spot was apparent on the cornea; on August 6 the other eye appeared to be affected also. Careful examination of the eyes, however, failed to reveal any of the parasites. The inference is that the embryos did not develop, and that the slight affection of the eyes noted was due to other causes.

Further attempts at infection have been made, but with negative results. Eggs containing embryos were placed in the eye of a young fowl February 26, 1904. On the same date, also, eggs containing embryos were fed to a young fowl and to a full-grown hen. Both young chickens died April 4. No eye worms were found on post-mortem examination. Examination of the remaining chicken to which eggs had been fed showed that eye worms were absent April 19.

These few incomplete experiments, all resulting negatively, will warrant no definite conclusions concerning the life history of *Oxyspirura Mansoni*. It seems probable, however, that it is necessary for the embryos to pass a certain period of their existence either free or in an intermediate host before they will develop to maturity. If further investigations continue to show, as all observations so far have shown, that the parasite is restricted to localities bordering on the sea-coast, this fact will be of considerable significance in connection with the life history, indicating either that some marine form serves the

parasite as an intermediate host, or that certain conditions, peculiar to the seashore but yet unknown, are necessary to enable the parasite to complete the cycle of its development.

The entire question of the life history of *Oxyspirura Mansoni*, therefore, still remains to be solved.

GENERAL REVIEW OF NEMATODES PARASITIC IN THE EYES OF BIRDS.

In connection with the study of *Oxyspirura Mansoni* it was found, so far as was possible to trace in the literature, that only one other nematode (" *Filaria oculi*," p. 20) has been recorded parasitic in the eyes of birds in the United States. Taking the entire world, however, about 38 species, altogether, have been reported, collected from the eyes of about 43 different species of birds. It therefore seems very evident that a considerable number of species probably occur in the eyes of birds in the United States which have hitherto been overlooked, chiefly, it is presumed, on account of a lack of due attention by collectors of parasites to the eyes of animals examined. The fact that over half the known species are the result of the work of a single collector (Natterer) of South American birds would indicate that the eyes are much more frequently the location of nematode parasites than is commonly supposed.

Since the literature concerning the nematodes parasitic in the eyes of birds is scattered in numerous publications, mostly foreign and not generally available, it is believed that a summary of our knowledge concerning them will be found useful. Such a summary seems especially desirable, not only because these parasites are of particular interest in the present connection, but because a résumé of the forms in question may, in the first place, serve to direct attention to a neglected but important field, and, in the second place, afford a convenient and readily accessible basis of reference. The following review includes practically all the nematodes which have been reported up to the present time from the eyes of birds. The synonymy and bibliography are based upon the card catalogue of the Zoological Laboratory.

LIST OF SPECIES, WITH SYNONYMY AND SPECIFIC DIAGNOSES.

GENUS *OXYSPIRURA* DRASCHE (IN STOSSICH, 1897).

GENERIC DIAGNOSIS.—Filaridiæ: Mouth without lips, surrounded by two lateral and four submedian papillæ. Pharynx present. Membranous ale on head generally lacking. Tail usually slender and acutely pointed.

Tail of male without bursal membranes, and with papillæ. Spicules two, unequal; one long and filiform; the other short and thick. Vulva as a rule situated in the posterior part of the body, a short distance in front of the anus.

TYPE SPECIES.—*Oxyspirura cephaloptera* (Molin, 1860) Stossich, 1897.^a

^a See nematode check-list, by Stiles & Hassall (MS.).

OXYSPIRURA ANACANTHURA (MOLIN, 1860) STOSSICH, 1897.

(Figs. 10, 11.)

SYNONYMY AND BIBLIOGRAPHY.

- 1860: *Spiroptera anacanthura* MOLIN, 1860, pp. 966-967, 993.—DIESING, 1861a, p. 678.—LINSTOW, 1878, p. 71.—IDEM, 1889, p. 29.—DRASCHE, 1884a, pp. 203, 213, pl. 14, figs. 15, 16.—STOSSICH, 1897, p. 123 [as synonym of *Oxyspirura anacanthura*].
 1860: *Spiroptera crotophagæ ani* MOLIN, 1860, p. 966 [as synonym of *S. anacanthura*].
 1860: *Spiroptera crotophagæ majoris* MOLIN, 1860, p. 966 [as synonym of *S. anacanthura*; not *S. crotophagæ majoris* Molin, 1860, p. 940=*S. lanceolata* Molin].
 1897: *Oxyspirura anacanthura* (Molin, 1860) STOSSICH, 1897, pp. 123-124, 148.

SPECIFIC DIAGNOSIS.—*Oxyspirura*: Body straight and slender, gradually attenuated toward both ends, truncated anteriorly and acutely pointed posteriorly without mucronate caudal tip. Head with two voluminous lateral cuticular membranes.^a Mouth large, circular, surrounded by six very small membranous lobules, and four submedian papillæ. Pharynx short. Cuticula of body closely striated transversely.

Male: 8 to 10 mm. long by 0.1 mm. thick. Caudal extremity coiled in a single turn, without bursal membranes; two pairs of (?) preanal papillæ, and a variable number of asymmetrically arranged postanal papillæ, up to as many as five pairs. Spicules two, unequal; right spicule short, thick-set, with boat-shaped tip; left spicule filiform, acutely pointed, alate, five times as long as the right spicule.

Female: 11 to 13 mm. long by 0.2 mm. thick. Vulva prominent, a short distance anterior of anus.

HABITAT.—Common smooth-billed ani, *Crotophaga ani*; under nictitating membrane; Brazil (Molin, 1860).—Greater ani, *Crotophaga major*; under nictitating membrane; Brazil (Molin, 1860).

TYPE SPECIMENS.—In Vienna Museum.

Molin (1860, p. 966) based this species on nine males and two females from *Crotophaga ani* collected by Natterer in 1829, and four males and six females from *C. major* collected by Natterer in 1825. All but three were well preserved and perfectly transparent. The original material was reexamined by Drasche (1884a).

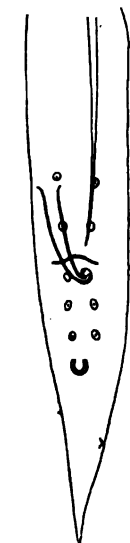


FIG. 10.—*Oxyspirura anacanthura*. Posterior end of male. $\times 60$. (Haines del., after Drasche, 1884a, pl. 14, fig. 15.)

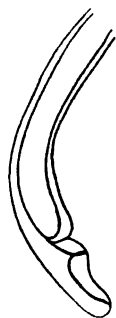


FIG. 11.—*Oxyspirura anacanthura*. Right spicule. $\times 280$. (Haines del., after Drasche, 1884a, pl. 14, fig. 16.)

[?OXYSPIRURA] ANOLABIATA (MOLIN, 1860) RANSOM, 1904.

(Fig. 12.)

SYNONYMY AND BIBLIOGRAPHY.

- 1860: *Spiroptera anolabiata* MOLIN, 1860, pp. 981, 992.—LINSTOW, 1878, p. 124.—IDEM, 1889, p. 47.—DRASCHE, 1884a, p. 206, pl. 12, fig. 23.—STOSSICH, 1897, p. 51 [as synonym of *Filaria anolabiata*].
 1860: *Spiroptera cracis alectoris* MOLIN, 1860, p. 981 [as synonym of *S. anolabiata*].
 1897: *Filaria anolabiata* (Molin, 1860) STOSSICH, 1897, pp. 51, 149.
 1904: [? *Oxyspirura*] *anolabiata* (Molin, 1860) RANSOM, 1904, p. 21.

^a Molin (1860, p. 966) describes four membranes on the head arranged in the form of a cross, but Drasche (1884a, p. 203), who examined Molin's original material, failed to find this structure.

SPECIFIC DIAGNOSIS.—? *Oxyspirura*:

Male: Unknown.

Female: 8 to 17 mm. long by 0.4 mm. thick. Anterior end of body abruptly attenuated with truncated apex. Cuticular rings with sharply cut posterior border encircle the body. Mouth large, surrounded by six small lips or lobes, two lateral and four submedian. In relation with each lip is a finger-like process extending inward from the periphery of the head. These processes divide the annular border of the mouth into six lobes. Mouth opens into a broad short pharynx. Tail straight, abruptly conical, with blunt curved tip. Position of vulva not determined.



FIG. 12.—[? *Oxyspirura*] *anolatiata*. Lateral view of head. $\times 290$. (Haines del., after Drasche, 1884a, pl. 12, fig. 23.)

HABITAT.—Spix curassow, *Crax fasciolata*; under nictitating membrane and free in the eye; Brazil (Molin, 1860).

TYPE SPECIMENS.—In Vienna Museum.

This species is based upon specimens of five females, collected by Natterer in 1825 and 1827. It was listed with *species inquirendæ* by Molin, on account of the lack of specimens of the male. The original material was reexamined by Drasche (1884a). It is very probable that this species belongs in the genus *Oxyspirura*. There is a striking similarity between the figure (fig. 12) given by Drasche (1884a), and the head of *Oxyspirura Mansoni* (fig. 3).

[? *OXYSPIRURA*] *BREVIPENIS* (MOLIN, 1860) STOSSICH, 1897.

(Fig. 13.)

SYNONYMY AND BIBLIOGRAPHY.

1860: *Spiroptera brevipenis* MOLIN, 1860, pp. 921, 991.—DIESING, 1861a, p. 676.—LINSTOW, 1878, p. 137.—IDEM, 1889, p. 51.—DRASCHE, 1884a, pp. 194, 212, pl. 14, fig. 14.—STOSSICH, 1897, p. 126 [as synonym of *Oxyspirura brevipenis*].

1860: *Spiroptera microdactyli margravii* MOLIN, 1860, p. 921 [as synonym of *Spiroptera brevipenis*].

1897: *Oxyspirura brevipenis* (Molin, 1860) STOSSICH, 1897, pp. 126, 150.

SPECIFIC DIAGNOSIS.—? *Oxyspirura*: Body straight, slender, fili-form. Anterior extremity attenuated with truncated apex. Mouth large, orbicular, without lips or papillæ. Pharynx absent.

Male: 16 to 22 mm. long by 0.4 mm. thick. Tail coiled in two turns, bodkin-shaped with sharp point, and without bursal membranes; six pairs of preanal and six pairs of postanal papillæ, the latter inconstant in number and asymmetrical in arrangement. Spicules two, nearly equal, very short, curved, saber-like.

Female: 11 to 27 mm. long by 0.1 to 0.5 mm. thick. Tail straight, slender, conical, with thickened tip. Anus remote from caudal tip. Vulva near anus, prominent, with swollen posterior lip.

HABITAT.—*Dicholophus margravi* [=seriema, *Cariama cristata*]; under nictitating membrane; Brazil (Molin, 1860).

TYPE SPECIMENS.—In Vienna Museum.

Molin (1860, p. 921) based his description of this species on seventeen male and twenty-one female specimens, collected by Natterer in

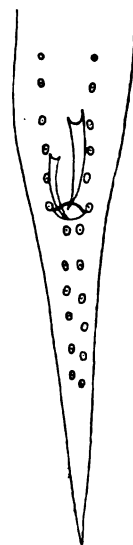


FIG. 13.—[? *Oxyspirura*] *brevipenis*. Posterior end of male. $\times 60$. (Haines del., after Drasche, 1884a, pl. 14, fig. 14.)

1824, all well preserved and perfectly transparent. The original material was redescribed by Drasche (1884a).

The absence of a pharynx, and the occurrence of short, nearly equal spicules makes it very doubtful whether this species can be classed in the genus *Oryspirura*.

OXYSPIRURA BREVISUBULATA (MOLIN, 1860) STOSSICH, 1897.

SYNONYMY AND BIBLIOGRAPHY.

- 1860: *Spiroptera brevisubulata* MOLIN, 1860, pp. 959-960, 998.—DIESING, 1861a, p. 677.—DRASCHE, 1884a, pp. 201-202.—LINSTOW, 1889, p. 40.—PARONA, 1889, p. 775.—STOSSICH, 1897, p. 124 [as synonym of *Oryspirura brevisubulata*].
 1860: *Spiroptera strigia* N. 16 MOLIN, 1860, p. 960 [as synonym of *Spiroptera brevisubulata*; not *Spiroptera strigia* Rudolphi, 1819, p. 28; not *S. strigia* N. 16 Molin, 1860, p. 939—*S. penhamata*].
 1878: *Spiroptera brevisubulata* (Molin, 1860) LINSTOW, 1878, p. 105 [misprint for *Spiroptera brevisubulata*].
 1897: *Oryspirura brevisubulata* (Molin, 1860) STOSSICH, 1897, p. 124.

SPECIFIC DIAGNOSIS.—*Oryspirura*: Body filiform, gradually attenuated anteriorly with truncated apex; two lateral cervical spines directed backward. Cuticula raised from the body between the head and cervical papillae forming a bladder-like expansion on either side.^a Mouth hexagonal, without lips, surrounded by two lateral and four submedian papillae.

Male: 15 mm. long by 0.3 mm. thick. Tail coiled in two turns, short, abruptly subulate, with acute point. Bursa absent; four pairs preanal and (?) eight pairs postanal papillae. Spicules two, unequal; right spicule short and thick; left spicule filiform and twice as long as the right.

Female: 21 mm. long by 0.5 mm. thick. Tail short, subulate, with acute point. Anus remote from caudal tip. Vulva very prominent, a short distance anterior of the anus.

HABITAT.—*Strix atricapilla* [= Brazilian screech owl, *Otus choliba*]; under nictitating membrane; Brazil (Molin, 1860).

TYPE SPECIMENS.—In Vienna Museum.

This species is based on specimens of two males and one female, badly preserved and opaque, collected by Natterer in 1826 (Molin, 1860, p. 960). The original material was redescribed by Drasche (1884a).

OXYSPIRURA CEPHALOPTERA (MOLIN, 1860) STOSSICH, 1897.

(Figs. 14, 15.)

SYNONYMY AND BIBLIOGRAPHY.

- 1860: *Spiroptera cephaloptera* MOLIN, 1860, pp. 956-957, 994, 997.—DIESING, 1861a, p. 686 [as synonym of *Cheilospirura cephaloptera*].—LINSTOW, 1878, pp. 73, 97.—IDEM, 1889, p. 30.—DRASCHE, 1884a, p. 213 [as synonym of *Cheilospirura cephaloptera*].—STOSSICH, 1897, p. 124 [as synonym of *Oryspirura cephaloptera*].
 1860: *Spiroptera momoti brasiliensis* MOLIN, 1860, p. 957 [as synonym of *S. cephaloptera*].
 1860: *Spiroptera oriolii* N. 642 MOLIN, 1860, p. 957 [as synonym of *S. cephaloptera*].
 1861: *Cheilospirura cephaloptera* (Molin, 1860) DIEING, 1861a, p. 686.—DRASCHE, 1884a, p. 212, pl. 11, fig. 22, pl. 14, fig. 17.—STOSSICH, 1897, p. 124 [as synonym of *Oryspirura cephaloptera*].
 1897: *Oryspirura cephaloptera* (Molin, 1860) STOSSICH, 1897, pp. 124-125, 145, 147.

SPECIFIC DIAGNOSIS.—*Oryspirura*: Body gradually attenuated anteriorly, with rounded apex; tail awl-shaped, drawn out into a slender acute point. Cuticula

^a Drasche (1884a, p. 202), who examined Molin's original material, failed to find the four membranous ale on the head mentioned by the latter author.

densely striated transversely. Head with membranous alæ dilated and rounded anteriorly. Mouth hexagonal surrounded by a membranous border, and two lateral and four submedian papillæ. Lips absent.^a

Male: 13 to 15 mm. long by 0.2 mm. thick. Tail coiled twice. Bursa absent; seven pairs preanal and six pairs postanal papillæ, the latter more or less inconstant and asymmetrical. Spicules two, unequal; right spicule short, thick, navicular, with blunt rounded tip; left spicule filiform, pointed, alate, five times as long as the right.



FIG. 14.—*Oxysepirura cephaloptera*. Anterior view of head. $\times 470$. (Haines del., after Drasche, 1884a, pl. 11, fig. 22.)

Female: 10 to 13 mm. long by 0.3 mm. thick. Anus remote from tip of tail. Position of vulva not determined.

HABITAT.—*Momotus brasiliensis* [=motmot, *Momotus momota*]; under nictitating membrane; Brazil (Molin, 1860).—Orange-backed troupial, *Icterus croconotus*; under nictitating membrane; Brazil (Molin, 1860).

TYPE SPECIMENS.—In Vienna Museum.

The original description (Molin, 1860, pp. 956–957) is based on three males well preserved, and eight females badly preserved, collected by Natterer from *Momotus brasiliensis* in 1834, and two males well preserved and a fragment collected by Natterer from *Icterus croconotus* in 1824. The original material was reexamined by Drasche (1884a).

[? *OXYSEPIRURA*] *HETEROCLITA* (MOLIN, 1860) RANSOM, 1904.

SYNONYMY AND BIBLIOGRAPHY.

1860: *Spiroptera heteroclita* MOLIN, 1860, pp. 944–945, 992.—DIESING, 1861a, p. 677.—LINSTOW, 1878, p. 124.—STOSSICH, 1897, pp. 115, 149.

1860: *Spiroptera cracis* MOLIN, 1860, p. 944 [as synonym of *S. heteroclita*; not *S. cracis* N. of Molin, 1860, p. 983, as synonym of *S. tenuicauda*].

1904: [*Oxysepirura*] *heteroclita* (Molin, 1860) RANSOM, 1904, p. 24.

SPECIFIC DIAGNOSIS.—? *Oxysepirura*: Body attenuated anteriorly with truncated apex. Cuticula finely striated transversely. Mouth orbicular, large, without lips.

Male: 12 mm. long by 0.3 mm. thick. Head without membranes. Tail awl-shaped, sharply pointed, curved into a hook, without bursal membranes. Two pairs postanal papillæ. Spicules two, unequal; short spicule thick with curved point; long spicule filiform, half as long as body.

Female: 15 mm. long by 0.4 mm. thick. Head with four short, semilunar membranes, arranged in the form of a cross. Tail gradually attenuated, awl-shaped, with obtuse apex. Anus remote from tip. Position of vulva not determined.

HABITAT.—*Cxax urumutum* [=urumutu, *Nothocrax urumutum*]; under nictitating membrane; Brazil (Molin, 1860).

TYPE SPECIMENS.—In Vienna Museum.

This species is based on one male and one female, well preserved, collected by Natterer in 1834 (Molin, 1860, p. 945). So far as may be determined from Molin's incomplete description this species seems to belong in *Oxysepirura*.

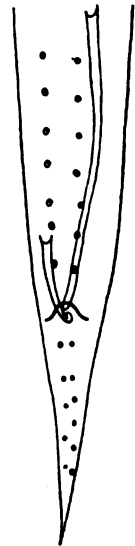


FIG. 15.—*Oxysepirura cephaloptera*. Posterior end of male. $\times 120$. (Haines del., after Drasche, 1884a, pl. 14, fig. 17.)

^aAccording to Drasche (1884a, p. 212); but Molin (1860, p. 956) mentions two large rounded lips.

OXYSPIRURA MANSONI (COBBOLD, 1879) RANSOM, 1904.

(Figs. 1-9.)

SYNONYMY AND BIBLIOGRAPHY.

- 1879: *Filaria Mansonii* COBBOLD, 1879b, pp. 440-441 [not *Filaria Mansonii* Huber, 1896, pp. 604, 620, used as synonym of *F. sanguinis hominis* and of *Trichina cystica* Salisbury.—SIMON, 1897, p. 97, copies Huber, 1896, p. 604].—IDEM, 1880k, p. 131.—MAGALHÃES, 1888, pp. 5-12, figs. 1-6.—IDEM 1896, pp. 241-244.—NEUMANN, 1888, p. 648.—IDEM, 1892 [French ed.], p. 735.—IDEM, 1892 [Eng., ed.], p. 759.—LINSTOW, 1889, p. 46.—RAILLIET, 1893, p. 533.—STROSSICH, 1897, pp. 35, 149.—GEDOELST, 1903a, p. 47.—IDEM, 1903a, p. 90 [as synonym of *Spiroptera Mansonii*].
- 1901: *Spiroptera Emmerzei* EMMEREZ & MÉGNIN, 1901a, pp. 933-935, figs. A-E.
- 1903: *Spiroptera Mansonii* (Cobbold, 1879) GEDOELST, 1903, pp. 90, 103.
- 1903: *Spiroptera Emmerzei* (Emmerze & Mégnin, 1901) GEDOELST, 1903, p. 48.—IDEM, 1903a, p. 90 [as synonym of *Spiroptera Mansonii*].
- 1904: *Oxyspirura Mansonii* (Cobbold, 1879) RANSOM, 1904, pp. 7-20, 25.

SPECIFIC DIAGNOSIS.—*Oxyspirura*: Body attenuated at both ends, anterior end rounded, posterior end pointed. Cuticula smooth. Membranous appendages absent in both sexes. A pair of small cervical papillæ 350 to 400 μ from anterior end, and a pair of small papillæ near tip of tail in both sexes. Mouth circular, surrounded by a six-lobed chitinous ring; two lateral and four submedian papillæ in relation with the clefts between the lobes of ring; four sublateral papillæ slightly more posterior. Excretory pore in ventral line at about the level of cervical papillæ. Nerve ring between excretory pore and anterior end of body, about 250 μ from latter. Pharynx 40 to 60 μ long; the shorter, wider, anterior portion, 15 to 25 μ long by 25 to 30 μ wide, separated by a slight constriction from the longer narrower posterior portion, 25 to 30 μ long by 20 to 25 μ wide. Esophagus club-shaped, about 1.5 mm. long. Intestine almost straight.

Male: 10 to 16 mm. long by 0.35 mm. thick. Tail curved ventrally. Bursal membranes lacking. Cloacal opening 320 to 400 μ from tip of tail. Two pairs postanal and four pairs preanal papillæ. Spicules two, unequal; one long and slender, 3 to 3.5 mm. long by 8 to 10 μ in diameter; the other short and thick, 200 to 220 μ long by 30 μ in diameter.

Female: 12 to 18 mm. long by 0.43 thick. Anus 400 to 530 μ from tip of tail. Vulva in posterior part of body, 1 to 1.4 mm. from tip of tail. Uterus and ovary double; vagina measures 1.5 to 2 mm. long. Eggs oval, 50 by 40 μ to 65 by 45 μ in diameter.

LIFE HISTORY.—Unknown. Embryos hatch in two or three days after eggs are deposited, measure 225 to 250 μ in length by 12 μ in thickness, with esophagus 50 μ long.

HABITAT.—Chicken, *Gallus domesticus*; under nictitating membrane; Amoy, China (Cobbold, 1879b); Rio de Janeiro, Brazil (Magalhães, 1888); Mauritius (Emmerze & Mégnin, 1901a); Laughlands, Jamaica, and Key West, Fla. (Ransom, 1904).—Peafowl, *Pavo cristatus*; under nictitating membrane; Rio de Janeiro, Brazil (Magalhães, 1888).

TYPE SPECIMENS.—[?]. Above diagnosis based on B. A. I. specimens Nos. 3182 and 3257.

This species is based on specimens of both sexes collected by Manson from chickens at Amoy, China (Cobbold, 1879b), but not described except as to length. Specimens collected and described by Magalhães (1888) in Brazil from chickens and peacock have been compared (Magalhães, 1895) with specimens collected by Manson and found to be of the same species as the latter.

OXYSPIRURA OPHTHALMICA (LINSTOW, 1903) RANSOM, 1904.

(Figs. 16-18.)

SYNONYMY AND BIBLIOGRAPHY.

1903: *Cheilospirura ophthalmica* LINSTOW, 1903, p. 111, pl. 5, figs. 7-9.

1904: *Oxyspirura ophthalmica* (Linstow, 1903) RANSOM, 1904, p. 26.

SPECIFIC DIAGNOSIS.—*Oxyspirura*: Cuticula finely striated transversely. Mouth surrounded by two lateral and four submedian papillæ. Pharynx short and

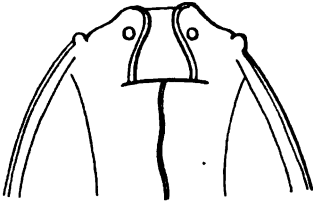


FIG. 16.—*Oxyspirura ophthalmica*. Head. Enlarged. (Haines del., after Linstow, 1903, pl. 5, fig. 7.)

widened posteriorly. Esophagus, in male $\frac{1}{4}$, in female $\frac{1}{2}$, the length of the body, is thickened behind and broader than the beginning of the intestine. Nerve ring 0.21 to 0.22 mm. from the anterior end. Lateral fields 0.042 mm. broad, i. e., about $\frac{1}{4}$ the circumference of the body; each contains an excretory vessel, 0.0028 mm. in diameter, visible through the cuticula. Excretory pore in ventral line 0.40 mm. from the anterior end in the male, 0.44 mm. in the female.

Male: 14.4 mm. long by 0.31 mm. in width. The conical, finely pointed tail equals $\frac{1}{2}$ of the entire body length. The two unequal spicules measure 0.18 and 0.29 mm. in length. One pair of preanal papillæ, and about twenty-six pairs of postanal papillæ decreasing gradually in size toward the anus are present. Testicle occupies only about the posterior $\frac{1}{4}$ of the body.

Female: 21 mm. long by 0.53 mm. in width. Tail conical, equal in length to $\frac{1}{3}$ of the entire body. Uteri occupy the posterior $\frac{1}{3}$ of the body. Vulva near posterior end, dividing the body in the ratio of 102 to 5. Vagina runs anteriorly from vulva; 0.4 mm. from the latter divides into two uteri. Eggs thick-shelled, 0.039 mm. long by 0.026 mm. broad; cleavage takes place in the uterus.

HABITAT.—Indian bustard-quail, *Turnix taigoor*; eye; Siam (Linstow, 1903).

TYPE SPECIMENS.—? In collection Linstow.

This species is based on specimens received from A. E. Shipley by Linstow (1903, p. 111).

Linstow classified the species under discussion in the genus *Cheilospirura*, evidently because of the similarity between it and *Oxyspirura cephaloptera* (= *Cheilospirura cephaloptera*). Such an arrangement seems, however, entirely untenable, unless it be also held that *cephaloptera*, one of the original species of *Oxyspirura*, is the type species

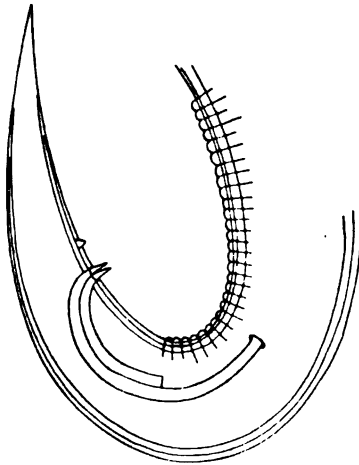


FIG. 17.—*Oxyspirura ophthalmica*. Posterior end of male. Side view. Enlarged. (Haines del., after Linstow, 1903, pl. 5, fig. 8.)

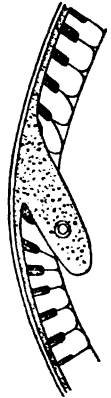


FIG. 18.—*Oxyspirura ophthalmica*. Transverse section through the lateral field of body wall. Enlarged. (Haines del., after Linstow, 1903, pl. 5, fig. 9.)

of *Cheilospirura*, with which genus it was listed by Diesing. In the original publication of the genus, Diesing (1861a, pp. 683–686), without definitely designating a type, defines the group as consisting of *Spiroptera spec. bilabiata* Molin, and includes eight species, the last of which in the list is a *species inquirenda*, and the next to the last *cephaloptera*.

Since the chief character upon which Diesing founded the genus is the presence of two lips, it is not only desirable but practically imperative, other things being equal, to confine the choice of a type to such species as present this character. Although Molin (1860) mentions two large rounded lips, Drasche (1884a), who made a study of the material upon which Molin based the original description, states that the species *cephaloptera* is without lips. Of the six remaining species, five are characterized by the possession of two lips. One of the latter should therefore be selected as type rather than *cephaloptera* which seems to be without lips.

Unless *cephaloptera* be taken as type of *Cheilospirura*, which has been shown to be virtually out of the question, the inclusion of *Oxyspirura* in *Cheilospirura* would result in grouping together forms which, according to present generally accepted ideas, vary too widely to rank in the same genus, and I therefore prefer to recognize two distinct genera. The species *ophthalmica*, as well as the species *siamensis*, of Linstow, I have accordingly transferred to the genus *Oxyspirura*.

[?OXYSPIRURA] PAPILLOSA (MOLIN, 1860) RANSOM, 1904.

(Figs. 19, 20.)

SYNONYMY AND BIBLIOGRAPHY.



FIG. 19.—[?Oxyspirura] papillosa. Anterior view of head. $\times 280$. (Haines del., after Drasche, 1884a, pl. 12, fig. 20.)

1860: *Spiroptera papillosa* MOLIN, 1860, pp. 929–930, 998.—DIESING, 1861a, p. 676.—LINSTOW, 1878, pp. 110, 115.—IDEM, 1889, p. 41.—DRASCHE, 1884a, p. 195, pl. 12, fig. 20; pl. 13, fig. 7.—STROSSICH, 1897, pp. 95, 141.

1860: *Spiroptera falconis leptopodis* MOLIN, 1860, p. 930 [as synonym of *S. papillosa*].

1860: *Spiroptera falconis gavial realis* MOLIN, 1860, p. 930 [as synonym of *S. papillosa*].

1860: *Spiroptera falconis* MOLIN, 1860, p. 930; *S. falconis* N. 872 MOLIN, 1860, p. 930 [as synonyms of *S. papillosa*; not *S. falconis* Rudolphi,

1819, pp. 28, 254–255; not *S. falconis* N. 698, *S. falconis* N. 11 Molin, 1860, p. 494, as synonyms of *Dispharagus rectus* Molin].

1904: [?Oxyspirura] papillosa (Molin, 1860) RANSOM, 1904, p. 27.

SPECIFIC DIAGNOSIS.—?Oxyspirura: Anterior end of body abruptly attenuated with very obtuse rounded apex. Surface of body crenated with dense cuticular annulations. Neck armed with rows of very delicate spines directed backward, each row

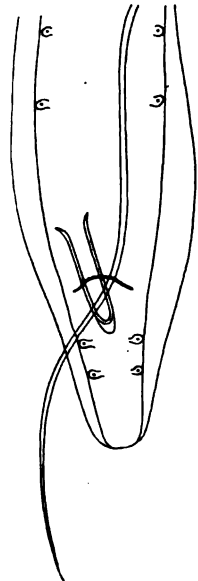


FIG. 20.—[?Oxyspirura] papillosa. Posterior end of male. $\times 120$. (Haines del., after Drasche, 1884a, pl. 13, fig. 7.)

corresponding to a cuticular ring. Mouth large, orbicular, with tumid border. Lips absent; two lateral and four submedian head papillae.

Male: 8 to 20 mm. long by 0.3 mm. thick. Tail of male more attenuated than anterior end, with very obtuse rounded tip, only slightly curved; four pairs of small preanal papillae situated far forward (according to Molin, seven pairs of preanal papillae) and two pairs of postanal papillae. Spicules two, unequal; right spicule very short and broad with blunt point; left spicule six times as long as the right, slender, filiform, alate.

Female: 15 to 26 mm. long by 0.3 to 0.5 mm. thick. Tail gradually attenuated with rounded obtuse tip. Anus remote from caudal tip, prominent, with bilabiate tumid border. Vulva in anterior part of body not far posterior of the mouth.

HABITAT.—*Falco destructor* [=harpy eagle, *Thrasnetus harpyia*]; under nictitating membrane; Brazil (Molin, 1860).—*Falco gracilis* [=gray crane hawk, *Geranospizias caerulescens*]; under nictitating membrane; Brazil (Molin, 1860).

TYPE SPECIMENS.—In Vienna Museum.

This species is based on specimens described by Molin (1860, p. 930) and reexamined by Drasche (1884a, p. 195). Of these, 5 females were collected by Natterer in 1833, 6 females in 1834, and 8 males and 12 females in 1833, all from *Falco destructor*, and 2 males and 1 female in 1826 from *Falco gracilis*. The characters given agree in the main with those typical of *Oxyrura*, and the species may be referred provisionally to that genus.

OXYSPIRURA SIAMENSIS (LINSTOW, 1903)
RANSOM, 1904.

(Fig. 21.)

SYNONYMY AND BIBLIOGRAPHY.

- 1903: *Cheilospirura siamensis* LINSTOW, 1903, p. 112, pl. 5, fig. 10.
1904: *Oxyrura siamensis* (Linstow, 1903) RANSOM, 1904, p. 28.

SPECIFIC DIAGNOSIS.—*Oxyrura*: Cuticula very finely striated transversely. Pharynx small. Esophagus, in male $\frac{1}{11}$, in female $\frac{1}{13}$, of the entire body length, is widened behind to a diameter somewhat greater than that of the intestine. Nerve ring situated $\frac{2}{10}$, excretory pore $\frac{6}{10}$, of the length of the esophagus from the anterior end of the body. Posterior portion of esophagus separated from remainder by a con-

FIG. 21.—*Oxyrura siamensis*. Posterior end of male. Side view. Enlarged. (Haines del., after Linstow, 1903, pl. 5, fig. 10.)

striction. Tail conical. Sexual organs lie in posterior half of body in both sexes.

Male: 8.9 mm. long by 0.26 mm. broad. Tail, curved ventrally, equals $\frac{1}{11}$ of the entire body length. Two unequal spicules 0.47 and 0.25 mm. long. About twenty-eight pairs preanal papillae becoming gradually smaller anteriorly.

Female: 9.8 mm. long by 0.46 mm. broad. Tail equals $\frac{1}{17}$ of the entire body length. Vulva opens a short distance anterior of anus, 0.62 mm. from tip of tail. Vagina runs anteriorly from vulva and 0.26 mm. from latter divides into two uteri.

HABITAT.—*Centropus siamensis* [=Indian ground cuckoo, *Centropus sinensis*]; probably from the eye; Siam (Linstow, 1903).

TYPE SPECIMENS.—? In collection Linstow.

This species is based on specimens received by Linstow (1903) from A. E. Shipley. I have placed this species in *Oxyspirura* for reasons given in the discussion of *Oxyspirura ophthalmica* (see p. 26).

[? OXYSPIRURA] STEREURA (RUDOLPHI, 1819) RANSOM, 1904.

SYNONYMY AND BIBLIOGRAPHY.

1819: *Spiroptera stereura* RUDOLPHI, 1819, pp. 23, 237, 555.—WESTRUMB, 1821, p. 69.—RAYER, 1843, p. 145.—GURLT, 1845a, p. 246.—DUJARDIN, 1845a, pp. 52, 93.—DIESING, 1851a, p. 212.—IDEM, 1861a, p. 678.—MOLIN, 1860, pp. 967, 999.—SCHNEIDER, 1866, pp. 78, 108 [as probably belonging in *Ceratospirura*].—LINSTOW, 1878, p. 113.—STOSSICH, 1889, p. 183.—IDEM, 1897, pp. 119-120, 142.
1904: [? *Oxyspirura*] *stereura* (Rudolphi, 1819) RANSOM, 1904, p. 29.

SPECIFIC DIAGNOSIS.—? *Oxyspirura*: Body slightly curved, thick, attenuated anteriorly with truncated apex. Cuticula annulated with numerous small campanuliform folds. Head without membranous appendages. Mouth orbicular without lips.

Male: 12 to 15 mm. long by 0.8 mm. thick. Tail coiled once spirally, without bursal membranes. Tip extended into a short appendage with knob-like end. Spicules two, unequal; short spicule, styloid with very acute point; long spicule, filiform. More than four pairs of preanal papillae (Schneider, 1866, p. 108).

Female: 12 to 17 mm. long by 1 mm. thick; 2 lateral cervical spines. Tail acutely conical, tip prolonged into a styloid appendage, with rounded knob-like extremity. Anus at base of appendage. (?) Vulva in anterior part of body.

HABITAT.—*Falco naevius* [= *Aquila naeva* = spotted eagle, *Aquila maculata*]; under nictitating membrane and in auditory meatus; Vienna (Rudolphi, 1819); orbit; Croatia (Stossich, 1889).

TYPE SPECIMENS.—? In Berlin or Vienna Museum.

This species is based on 1 male and 1 female specimen from the collection of the Vienna Museum (Rudolphi, 1819, p. 237). Specimens of 2 males and 4 females in the same collection were examined by Molin (1860, p. 967) and Rudolphi's original description added to. The characters given seem to warrant a provisional classification in the genus *Oxyspirura*.

OXYSPIRURA SYGMOIDEA (MOLIN, 1860) STOSSICH, 1897.

(Fig. 22.)

SYNONYMY AND BIBLIOGRAPHY.

1851: *Spiroptera anthuris* RUDOLPHI, 1819, of DIESING, 1851a, p. 215 [in part].—MOLIN, 1860, p. 920 [in part; as synonym of *Spiroptera sygmoidea*].
1860: *Spiroptera sygmoidea* MOLIN, 1860, pp. 920, 995.—DIESING, 1861a, p. 676.—DRASCHE, 1884a, pp. 194, 213, pl. 13, fig. 3.—STOSSICH, 1897, p. 125 [as synonym of *Oxyspirura sygmoidea*].
1878: *Spiroptera symoides* LINSTOW, 1878, p. 100 [misprint for *Spiroptera sygmoidea*].—IDEM, 1889, p. 38.
1878: *Filaria anthuris* LINSTOW, 1878, p. 100 [not *Filaria anthuris* (Rud.) Schneider, 1866, p. 96].
1897: *Oxyspirura sygmoidea* (Molin, 1860) STOSSICH, 1897, pp. 125, 146.

SPECIFIC DIAGNOSIS.—*Oxyspirura*: Body sygmoidal, attenuated at both ends, truncated anteriorly, slender and acutely pointed posteriorly. Cuticula finely striated transversely. Mouth large, orbicular, without lips; four submedian head-papillae.

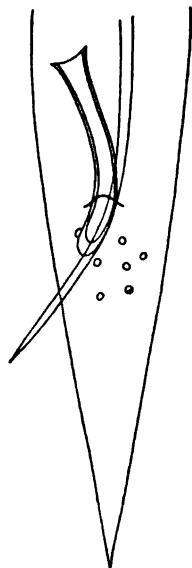


FIG. 22.—*Oxyspirura sygmoidea*. Posterior end of male. $\times 120$. (Haines del., after Drasche, 1884a, pl. 13, fig. 3.)

- 1819: *Filaria motacillarum* RUDOLPHI, 1819, p. 9 [as doubtful species and possible synonym of *F. turdorum*; no description; specimens not seen by Rudolphi; abdomen of *Motacilla rubecula* and of *Motacilla ananthe*; about the ears, cheeks, and neck of *Motacilla philomela*.—DIESING, 1851a, p. 268 [in part, exclusive of specimens from *Sylvia philomela*; as synonym of *F. abbreviata*.—MOLIN, 1858, p. 397 [follows Diesing, 1851a].—STROSSICH, 1897, p. 57 [as synonym of *F. abbreviata*].
- 1819: *Filaria motacillæ* RUDOLPHI, 1819, pp. 635-636 [as doubtful species and synonym of *F. motacillarum*; abdomen of *Muscicapa* N. 144, Brazil].—DIESING, 1851a, p. 268 [as synonym of *F. abbreviata*].—MOLIN, 1858, p. 397 [as synonym of *F. abbreviata*].—STROSSICH, 1897, p. 57 [as synonym of *F. abbreviata*].
- 1851: *Sptroptera philomelæ* DIESING, 1851a, p. 226.—LINSTOW, 1878, pp. 87, 92.
- 1888: *Filaria abbreviata* MAGALHÃES, 1888, p. 11 [misprint for *Filaria abbreviata*].
- 1897: *Filaria philomelæ* DIESING of STROSSICH, 1897, p. 57 [error for *Sptroptera philomelæ*; as synonym of *F. abbreviata*].

SPECIFIC DIAGNOSIS.—*Filaria*: Body elongated, armed with deciduous spines arranged in longitudinal series; anterior extremity abruptly attenuated, truncated; posterior extremity thicker. Mouth without papillæ; infundibuliform pharynx supplied with six tooth-like organs, three on the dorsal and three on the inferior surface.

Male: 12 to 25 mm. long by 0.5 mm. thick. Caudal extremity curved, truncated. Spicules two, unequal; short spicule ensiform; long spicule twisted spirally.

Female: 30 to 50 mm. long by 0.5 to 1 mm. thick. Caudal extremity straight, obtuse.

HABITAT.—*Motacilla stapasina* [=Russet wheatear, *Saricola rufa*]; orbital cavity; ? Europe (Rudolphi, 1819).—*Motacilla melanocephala* [=Sardinian warbler, *Melizophilus melanocephalus*]; abdomen; ? Europe (Diesing, 1851a).—*Sylvia rubecula* [=robin redbreast, *Erithacus rubecula*]; abdomen; ? Europe (Diesing, 1851a).—*Sturnus pyrrhcephalus* [=scarlet-headed marsh bird, *Amblyramphus holosericeus*]; abdomen; Brazil (Molin, 1858).—*Thryothorus polyglottus* [=Brazilian short-billed marsh wren, *Cistothorus polyglottus*]; abdomen; Brazil (Molin, 1858).—*Tanagra jacapa* [=Jacapa tanager, *Ramphocelus jacapa*]; kidney; Brazil (Molin, 1858).—Red oven bird, *Furnarius rufus*; abdomen and kidneys; Brazil (Molin, 1858).—Pale-footed oven bird, *Furnarius leucopus*; abdomen; Brazil (Molin, 1858).

In the following hosts parasites have been found which have been identified provisionally as *Filaria abbreviata*: White wagtail, *Motacilla alba*; thoracic cavity; Europe (Walter, 1866).—Fieldfare, *Turdus pilaris*; abdomen; ? Europe (Rudolphi, 1819).—Mistletoe thrush, *Turdus viscivorus*; abdomen; ? Europe (Rudolphi, 1819).—*Motacilla rubecula* [=robin redbreast, *Erithacus rubecula*]; abdomen; ? Europe (Rudolphi 1819).—*Motacilla ananthe* [=wheatear, *Saricola ananthe*]; abdomen; ? Europe (Rudolphi, 1819).—*Motacilla philomela* [=thrush nightingale, *Aedon luscinia*]; about the ears, cheeks, and neck; ? Europe (Rudolphi, 1819).—*Muscicapa* sp. [=probably some species of Tyrannidæ]; abdomen; Brazil (Rudolphi, 1819).—*Falco naevius* [=spotted eagle, *Aquila maculata*]; eyes and nares; ? Europe (Rudolphi, 1819).—*Saricola* sp.; body cavity; Turkestan (Linstow, 1883).

TYPE SPECIMENS.—? In Berlin Museum.

The above description is taken from that given by Molin (1858, p. 396). Rudolphi's (1819, p. 210) original description based on 3 specimens, females, from the orbit of *Motacilla stapasina*, gives the length as 16 to 18 mm.; body of uniform thickness; head slender, obtuse; mouth orbicular; tail rounded; intestine of uniform thickness, dark yellow in color. A few remarks are made also concerning the female organs, but no distinctive characters are given.

Rudolphi (1819, p. 555) also describes briefly some worms from the collection of the Vienna Museum, said to have been taken from the ears and around the eyes of *Falco naevius*. These worms were apparently

of the same species as those from *Motacilla stapazina*. It seemed, however, doubtful to Rudolphi that birds so different should harbor the same species of parasite, and he therefore inclined to the belief that some error had been made in the identification of the one or the other host. He places the worms from *Falco naevius* in his list of doubtful forms. Subsequent authors have, however, generally included them with *Filaria abbreviata*. There were a number of males present, measuring 12 to 14 mm. in length, with a tail coiled once spirally, terminating in a very short point; spicule recurved. The females had a tail with a very short depressed tip.

[? *FILARIA*] *ARMATA* GESCHEIDT, 1833.

SYNONYMY AND BIBLIOGRAPHY.

1833: *Filaria armata* GESCHEIDT, 1833a, pp. 442-444, 445.—IDEM [1834a, p. 55].—RAYER, 1843, pp. 145-146, 148, 149 [includes translation of Gescheidt, 1833a, pp. 442-444].—CREPLIN, 1846b, pp. 160, 163, 172.—DIESING, 1851a, p. 275.—IDEM. 1861a, p. 703.—MOLIN, 1858, pp. 404, 443.—LEUCKART, 1876, v. 2, Lief. 3, p. 627.—LINSTOW, 1878, p. 112.—STOSSICH, 1897, pp. 60, 140.

SPECIFIC DIAGNOSIS.—? *Filaria*: *Species inquirenda*.

Male: Unknown.

Female: Body 7 mm. long by 1 mm. thick, slightly broader at the tail. Head with four nodular spines. Tail obtuse, rounded, with short, blunt mucronate tip.

HABITAT.—*Falco lagopus* [= rough-legged hawk, *Archibuteo lagopus*]; vitreous body of eye; ? Europe (Gescheidt, 1833a).

TYPE SPECIMENS.—The single specimen on which the species is based is probably not in existence.

? *FILARIA* *ATTENUATA* RUDOLPHI, 1802.

Linstow (1879, p. 315), in a list of parasites collected by Doctor von Hering, Stuttgart, mentions a worm from the eyes of the black crow, *Corvus corone*, considered possibly identical with *Filaria attenuata*. The specimens were very poorly preserved.

To this species Shipley (1903, p. 605) also refers provisionally a roundworm collected by Hawker in the Soudan from the orbit of an eagle owl (*Bubo* sp.). The species named, however, can scarcely come into consideration in this connection.

The original *Filaria attenuata* Rudolphi, 1802, came from crows, and though later Rudolphi assigned worms from hawks and falcons to the same species, Molin (1858, pp. 375-376, 394-395) has shown that the latter are a distinctly different species from the former, and that *F. attenuata* probably does not occur in the latter group of birds.

[? *FILARIA*] *BONASIE* RAYER, 1843.

SYNONYMY AND BIBLIOGRAPHY.

1832: *Filaria* sp. NORDMANN, 1832, pp. 16-17.—GESCHEIDT, 1833a, p. 423.—GUELT, 1845a, p. 263.—CREPLIN, 1846b, p. 175.
1843: *Filaria bonasie* RAYER, 1843, p. 149.—DUJARDIN, 1845a, p. 56.—DIESING, 1851a, p. 282.—MOLIN, 1858, pp. 426, 442.—LINSTOW, 1878, p. 120.—STOSSICH, 1897, pp. 62, 149.
1851: *Filaria tetraonis bonasie* DIESING, 1851a, p. 282 [as synonym of *Filaria bonasie*].—MOLIN, 1858, p. 426 [as synonym of *F. bonasie*].

SPECIFIC DIAGNOSIS.—? *Filaria*: *Species inquirenda*. Length 10 to 12 mm.; color white.

HABITAT.—*Tetrao bonasia* [=hazel hen, *Tetrastes bonasia*]; posterior chamber of eye; Gulf of Finland (Nordmann, 1832).

TYPE SPECIMENS.—Probably not in existence.

Reported but once; a single specimen collected.

[? *FILARIA*] *CAMPANULATA* MOLIN, 1858.

(Figs. 26-28.)

SYNONYMY AND BIBLIOGRAPHY.

1858: *Filaria campanulata* MOLIN, 1858, pp. 392-393, 448, pl. 2, figs. 5-7.—DIESING, 1861a, p. 702.—LINSTOW, 1878, p. 116.—STOSSICH, 1897, pp. 63, 141.

1858: *Filaria falconis magnirostris* MOLIN, 1858, p. 392 [as synonym of *F. campanulata*].

SPECIFIC DIAGNOSIS.—? *Filaria*:

Male: Unknown.

Female: 15 mm. long by 0.5 mm. thick. Anterior extremity of body attenuated, obtuse. Surface of body annulated; annulations campaniform, imbricated. Tail nearly straight, pointed. Vulva in anterior portion of body.

HABITAT.—*Falco magnirostris* [=large-billed hawk, *Rupornis magnirostris*]; under nictitating membrane; Brazil (Molin, 1858).

TYPE SPECIMENS.—In Vienna Museum.

This species is based upon a single specimen collected by Natterer in Brazil, and was placed in the genus *Filaria* by Molin (1858, p. 393) on account of the position of the vulva.

FILARIA CIRRURA LEIDY, 1886.

SYNONYMY AND BIBLIOGRAPHY.

1886: *Filaria cirrura* LEIDY, 1886, p. 309.—LINSTOW, 1889, p. 37.—STOSSICH, 1897, p. 64.

SPECIFIC DIAGNOSIS.—*Filaria*: Body cylindrical, nearly equal, cephalic end conical, rounded truncate, smooth; mouth a minute funnel-like orifice without papillæ or internal armature.

Male: 10 mm. long by 0.375 mm. thick. Caudal end closely rolled inward, conical, blunt, without alæ or papillæ; penial spiculæ strongly curved, with the points projecting from the prominent genital aperture situated above the tail end.

Female: 16 mm. long by 0.5 mm. thick. Caudal end slightly curved or nearly straight, conical, obtusely rounded, without appendages. [Vulva about 0.4 mm. from the cephalic end.]

HABITAT.—*Quiscalus major* [=boat-tailed grackle, *Megaquiscalus major*]; orbit; Florida (Leidy, 1886).

TYPE SPECIMENS.—In Helminthological Collection, U. S. National Museum, No. 66.

FIG. 26.—[? *Filaria*] *campanulata*. Female. Natural size. (Haines del., after Molin, 1858, pl. 2, fig. 5.)

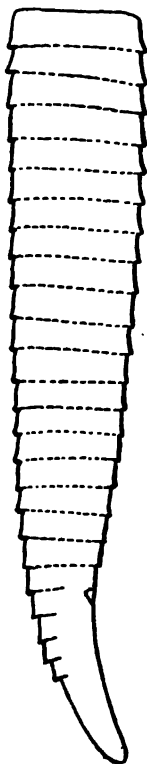


FIG. 28.—[? *Filaria*] *campanulata*. Posterior end of female. Enlarged. (Haines del., after Molin, 1858, pl. 2, fig. 7.)

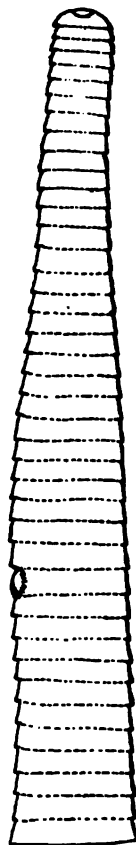


FIG. 27.—[? *Filaria*] *campanulata*. Anterior end of female. Enlarged. (Haines del., after Molin, 1858, pl. 2, fig. 6.)

The above diagnosis comprises the original description of Leidy (1886) which was based upon specimens of 4 females and 2 males. After examining the original material I am able to add one item to Leidy's diagnosis, namely, the position of the vulva.

[? FILARIA] DENDROCOLAPTIS PROCURVI LACRYMALIS MOLIN, 1858.

SYNONYMY AND BIBLIOGRAPHY.

- 1858: *Filaria dendrocolaptis procurvi lacrymalis* MOLIN, 1858, pp. 425, 443.
 1858: *Filaria dendrocolaptis* MOLIN, 1858, p. 425 [as synonym of *Filaria dendrocolaptis procurvi lacrymalis*; not *F. dendrocolaptis* Molin, 1858, p. 399—*Filaria quadriverrucosa* Molin, 1858, p. 398].
 1879: *Filaria dendrocolapti procurvi* LINSTOW, 1878, p. 80.
 1897: *Filaria dendrocolaptis procurvi* STOSSICH, 1897, pp. 67, 147.

SPECIFIC DIAGNOSIS.—? *Filaria: Species inquirenda*. Ten mm. long by 0.5 mm. thick. Anterior extremity of body pointed. Surface of body thickly striated transversely. Posterior extremity thickened, curved. Mouth without lips.

HABITAT.—*Dendrocolaptes procurvus* [=curve-bill woodhewer, *Xiphorhynchus procurvus*]; eye; Brazil (Molin, 1858).

TYPE SPECIMENS.—In Vienna Museum.

This form is listed among *species inquirendæ* by Molin (1858, p. 425). The sex of the single specimen examined by him could not be determined.

[? FILARIA] MYOTHERE CAMPANISONÆ MOLIN, 1858.

SYNONYMY AND BIBLIOGRAPHY.

- 1858: *Filaria myotheræ campanisonæ* MOLIN, 1858, pp. 425, 444.—LINSTOW, 1878, p. 81.—STOSSICH, 1897, pp. 74, 144.
 1858: *Filaria turdi* MOLIN, 1858, p. 425 [as synonym of *F. myotheræ campanisonæ*; not *F. turdi* Molin, 1858, p. 396, as synonym of *F. filiformis*; not *F. turdi* Molin, 1858, p. 423, as synonym of *F. turdi olivaceus* (palpebralis); not *F. turdi* n. sp. Linstow, 1877, pp. 173-174].

SPECIFIC DIAGNOSIS.—? *Filaria: Species inquirenda*.

Male: Unknown.

Female: 25 mm. long by 0.5 mm. thick. Anterior end of body attenuated, posterior end thickened.

HABITAT.—*Myothera campanisona* [=short-tailed ant thrush, *Chamaea brevicauda*]; eye; Brazil (Molin, 1858).

TYPE SPECIMENS.—In Vienna Museum.

Only a single opaque specimen of this species was examined by Molin (1858).

FILARIA OBTUSO-CAUDATA RUDOLPHI, 1819.

(Figs. 29, 30.)

SYNONYMY AND BIBLIOGRAPHY.

- 1819: *Filaria obtuso-caudata* RUDOLPHI, 1819, p. 634 [not *Filaria obtusocaudata* Schneider, 1866, p. 101—*Filaria Schneideri* Stossich, 1897].—DUJARDIN, 1845a, p. 55.—GÜRLT, 1845a, p. 250.—CREPLIN, 1846b, pp. 155, 160, 161, 172.—DIESING, 1851a, p. 277.—IDEM, 1861a, p. 710 [as synonym of *Monopetalonema obtuso-caudatum*].—MOLIN, 1858, pp. 413-414, 442, 443, 447.—LINSTOW, 1878, pp. 74, 75.—IDEM, 1879, pp. 315, 327.—PARONA, 1889, p. 762, fig. 4.—STOSSICH, 1897, pp. 37, 144, 148, 149.
 1819: *Filaria collurionis subcutanea* RUDOLPHI, 1819, pp. 8, 217 [in part; under skin of *Lanius minor* and *L. pomeranus*].—DIESING, 1851a, p. 274 [as synonym of *F. nodulosa*].—MOLIN, 1858, p. 413 [as synonym of *F. obtuso-caudata*].—DUJARDIN, 1845a, p. 52 [in part].—PARONA, 1889, p. 762 [as synonym of *F. obtuso-caudata*].
 1861: *Filaria nodulosa* RUDOLPHI, 1820 of DIESING, 1851a, pp. 274-275 [in part; under skin of *Lanius minor* and *L. pomeranus*].—MOLIN, 1858, p. 413 [as synonym of *F. obtuso-caudata*].—DIESING, 1861a, p. 710 [as synonym of *Monopetalonema obtuso-caudatum*].—PARONA, 1889, p. 762 [as synonym of *F. obtuso-caudata*].

- 1858: *Filaria tetraonis* MOLIN, 1858, p. 413 [as synonym of *F. obtuso-caudata*; not *F. tetraonis* Molin, 1858, p. 427 = *F. perdicis dentata*].
 1861: *Monopetalonema obtuse-caudatum* (Rudolphi, 1819) DIESING, 1861a, p. 710.—STOESICH, 1897, p. 37 [as synonym of *Filaria obtuso-caudata*].
 1879: *Menopetalonema obtus* [caudatum] LINSTOW, 1878, p. 74 [misprint for *Monopetalonema obtusecaudatum*; as synonym of *Filaria obtuso-caudata*].
 1883: ? *Filaria obtuso-caudata* LINSTOW, 1883, pp. 284-285.—IDEM, 1886, p. 10.

SPECIFIC DIAGNOSIS.—*Filaria*: Anterior end of body obtuse, with 8 nodules; posterior end gradually attenuated. Mouth bilabiate with unarmed truncate conical lips.

Male: 20 to 37 mm. long by 0.5 mm. thick. Tail curved, with a slender 5-ribbed membrane on each side. Spicules two, unequal, very straight and slender; long spicule 2.5 to 3 mm. long; short spicule 0.36 mm. long.

Female: 30 to 125 mm. long by 0.5 to 1 mm. thick. Tail straight, obtuse. Position of vulva not determined.



FIG. 29.—*Filaria obtuso-caudata*. Posterior end of male. Enlarged. (Haines del., after Parona, 1889, p. 762, fig. 4.)

HABITAT.—*Picus lineatus* [=lineated woodpecker, *Ceophloeus lineatus*]; thoracic cavity; Brazil (Rudolphi, 1819).—*Picus flavescens* [=black and yellow woodpecker, *Celeus flavescens*]; subcutaneous connective tissue of neck; Brazil (Diesing, 1851a); under skin of neck and superorbital region, and in walls of esophagus; Brazil (Molin, 1858).—*Picus robustus* [=Brazilian ivory-billed woodpecker, *Campephilus robustus*]; muscles of neck; Brazil (Diesing, 1851a).—*Picus passerinus* [=sparrow woodpecker, *Veniliornis passerinus*]; orbital cavity; ? Brazil (Diesing, 1851a); under skin of neck; Brazil (Molin, 1858).—*Picus aurulentus* [=Brazilian green woodpecker, *Chloronerpes aurulentus*]; muscles of neck; Brazil (Diesing, 1851a; Molin, 1858); under skin of neck; Brazil (Molin, 1858).—*Picus leucolæmus* [=white-throated green woodpecker, *Chloronerpes leucolæmus*]; subcutaneous connective tissue of neck; Brazil (Diesing, 1851a).—*Picus jumana* [=Jumana woodpecker, *Celeus jumana*]; muscles and subcutaneous connective tissue of neck; Brazil (Diesing, 1851a); under skin of and in tumor of neck; Brazil (Molin, 1858).—*Picus rubricollis* [=red-necked ivory-billed woodpecker, *Campephilus rubricollis*]; muscles of neck; Brazil (Diesing, 1851a); under skin of neck; Brazil (Molin, 1858).—Lesser gray shrike, *Lanius minor*; under skin; ? Europe (Rudolphi, 1819).—*Lanius pomeranus* [=pomerine shrike, *Lanius senator*, or rufous shrike, *Lanius rutilus*]; under skin; ? Europe (Rudolphi, 1819).—*Lanius rufus* [=rufous shrike, *Lanius rutilus*]; under skin near eye; ? Europe (Linstow, 1879).—*Lanius* sp.; underskin in occipital region; Abyssinia (Parona, 1889).

In the following host a parasite was found which was identified provisionally as *Filaria obtuso-caudata*.—*Lanius* sp.; ? location; Turkestan (Linstow, 1883).—*Perdix leucostrica* [=stellated partridge, *Odontophorus stellatus*]; wing muscles; Brazil (Molin, 1858).

TYPE SPECIMENS.—? In Vienna or Berlin Museum.

This species is based on a single specimen of female collected from the thoracic cavity of *Picus lineatus* by Natterer in Brazil. Rudolphi (1819, p. 634) described this specimen as slender, gradually attenuated posteriorly, with rather acute head, apex of tail very obtuse and short. Length, 20 mm. (15 lines). Mouth orbicular, unarmed. Two unequal spicules. Diesing (1851a, p. 277) enlarged slightly upon Rudolphi's



FIG. 30.—*Filaria obtuso-caudata*. Anterior end of female. Enlarged. (Haines del., after Parona, 1889, p. 762, fig. 4.)

original description and added a number of hosts. The description and list of hosts was still further extended by Molin (1858, pp. 413-414) and a part of *Filaria nodulosa* Rudolphi of Diesing (1851a), transferred to the species under discussion. Diesing (1861a, p. 710) placed this form in the genus *Monopetalonema*. Linstow (1879, 1883, 1886) and Parona (1889) have added one or two points to our incomplete knowledge of the anatomy of this form, and record new hosts and localities.

FILARIA OCULI OF "C. W. W.," 1891.

"C. W. W." (1891, p. 290) mentions a nematode found in the interior chamber of the eye of a parrot. No microscopic examination was made.

FILARIA PAPILLOSO-ANNULATA MOLIN, 1858.

SYNONYMY AND BIBLIOGRAPHY.

- 1851: *Filaria attenuata* RUDOLPHI OF DIESING, 1851a, p. 266 [in part; from the orbit of *Falco swainsonii*, Brazil].
 1858: *Filaria papilloso-annulata* MOLIN, 1858, pp. 399-400, 448.—DIESING, 1861a, p. 702.—LINSTOW, 1878, p. 118.—STOSSICH, 1897, pp. 75, 141.
 1858: *Filaria attenuata falconis picti* MOLIN, 1858, p. 400 [as synonym of *F. papilloso-annulata*; not *F. attenuata falconis picti* Molin, 1858, p. 392, as synonym of *F. verrucosa*.]

SPECIFIC DIAGNOSIS.—*Filaria*:

Male: Unknown.

Female: 50 mm. long by 1 mm. thick. Anterior end of body obtusely attenuated, closely annulated as far as the vulva. Mouth surrounded by eight papillæ. Posterior end of body thickened, with very acute caudal tip.

HABITAT.—*Falco swainsonii* [=Vigors hawk, *Gampsonyx swainsoni*]; in posterior region of orbit; Brazil (Diesing, 1851a).

TYPE SPECIMENS.—In Vienna Museum.

This species is based upon two female specimens (Molin, 1858, p. 400) collected by Natterer, the same apparently as those from the orbit of *Falco swainsonii* mentioned by Diesing (1851a) and identified by him as *Filaria attenuata*.

[? FILARIA] SYLVIE DIESING, 1851.

SYNONYMY AND BIBLIOGRAPHY.

- 1832: *Filaria* sp. NORDMANN, 1832, p. 17.
 1851: *Filaria sylvie* NORDMANN OF DIESING 1851a, p. 281 [not *F. sylvie* Molin, 1858, p. 425, as synonym of *F. myotherx chrysopygæ*].—MOLIN, 1858, pp. 423, 447.—LINSTOW, 1878, p. 86.—STOSSICH, 1897, pp. 82, 143.

SPECIFIC DIAGNOSIS.—? *Filaria*: *Species inquirenda*.

Length, 37.5 mm.

HABITAT.—*Sylvia aetina* [=chiffchaff, *Phylloscopus minor*]; orbital cavity; Germany (Nordmann, 1832.)

TYPE SPECIMENS.—Probably not in existence.

Reported but once. A single specimen collected by Doctor Gloger in Breslau (Nordmann, 1832, p. 17).

[? *FILARIA*] *TINAMI VARIEGATI* MOLIN, 1858.

SYNONYMY AND BIBLIOGRAPHY.

1856: *Filaria tinami variegati (palpebralis)* MOLIN, 1858, pp. 427, 441.

1858: *Filaria tinami variegati* MOLIN, 1858, p. 427 [as synonym of *F. tinami variegati (palpebralis)*].—LINSTOW, 1878, p. 125.—STOSSICH, 1897, p. 83.

1856: ? *Filaria labiotruncata* MOLIN, 1858, p. 427 [as possible synonym of *F. tinami variegati (palpebralis)*].

SPECIFIC DIAGNOSIS.—? *Filaria*: *Species inquirenda*.

No description.

HABITAT.—*Tinamus variegatus* [=variegated tinamou, *Crypturus variegatus*]; under nictitating membrane; Brazil (Molin, 1858).

TYPE SPECIMENS.—In Vienna Museum.

Molin (1858, p. 427) examined a single specimen collected by Natterer in poor state of preservation, which seemed to be a female belonging to *Filaria labiotruncata*, but he separated it from the latter on account of the difference in habitat.

[? *FILARIA*] *TURDI OLIVASCENTIS (PALPEBRALIS)* MOLIN, 1858.

SYNONYMY AND BIBLIOGRAPHY.

1858: *Filaria turdi olivascens (palpebralis)* MOLIN, 1858, pp. 423, 446.

1858: *Filaria turdi* MOLIN, 1858, p. 423 [not *F. turdi* Molin, 1858, p. 396 = *F. aliformis*; not *F. turdi* Molin, 1858, p. 425 = *F. myotheræ campanisonæ*; not *F. turdi* Linstow, 1877, pp. 173-174.]

1878: *Filaria turdi olivascens* LINSTOW, 1878, p. 90.—STOSSICH, 1897, pp. 85, 143.

SPECIFIC DIAGNOSIS.—? *Filaria*: *Species inquirenda*. No description.

HABITAT.—*Turdus olivascens* [identity of host unknown; this name not found in ornithological literature]; under nictitating membrane; Brazil (Molin, 1858).

TYPE SPECIMENS.—In Vienna Museum.

Molin (1858) remarks that the two specimens of this form collected by Natterer were in too bad condition to be studied.

GENUS **SPIROPTERA**^a RUDOLPHI, 1819.

GENERIC DIAGNOSIS.—Filariidæ: Scarcely distinguishable from *Filaria*. Body generally shorter and thicker. Vulva usually at a considerable distance from anterior end of body. Tail of male rolled spirally and furnished with lateral membranes.

TYPE SPECIES.—Probably *Spiroptera euryoptera* Rudolphi, 1819.^b

? *SPIROPTERA* *CAPRIMULGI* MOLIN, 1860.

Shipleigh (1903, p. 606) mentions a worm from the orbit of a "Night jar" (*Caprimulgus europæus* or *C. ægyptius*) collected by R. M. Hawker in the Soudan, and refers it provisionally to *Spiroptera caprimulgi* Molin, a species based upon a single specimen collected in Brazil from the stomach walls of *Cuprimulgus megalurus* and listed among *species inquirendæ* by the latter author.

^aAs will be shown in a forthcoming check list of the nematodes by Stiles and Hassall, the name *Acuaria* Bremser, 1811, must replace the name *Spiroptera*, as the latter is simply the genus *Acuaria* renamed. Since the generic relationship of each of the three species, *caprimulgi* of Shipleigh, *feai*, and *tenuicauda*, is very doubtful, I have, in order to avoid a multiplication of names, retained in the present paper the name *Spiroptera*, with which the species in question were originally listed.

^bSee nematode check-list by Stiles & Hassall (MS.).

[? SPIROPTERA] FEAI STOSSICH, 1897.

SYNONYMY AND BIBLIOGRAPHY.

1889: *Spiroptera* sp. PARONA, 1889, pp. 775, 779.—STOSSICH, 1897, p. 114 [as synonym of *S. Feai* Stossich].
 1897: *Spiroptera Feai* STOSSICH, 1897, pp. 114, 142.

SPECIFIC DIAGNOSIS.—? *Spiroptera*:

Male: Unknown.

Female: 16 mm. long by 1 mm. thick. Head rounded, with two conical papillæ. Caudal extremity very obtuse, not pointed.

HABITAT.—Burmese hawk-owl, *Ninox scutulata*; orbital cavity, behind the eyeball; Burma (Parona, 1889).

TYPE SPECIMENS.—[?]

This species is based on Parona's (1889) description of material collected by Leonardo Fea in Burma. On account of our incomplete knowledge of the anatomy of this form its classification in the genus *Spiroptera* may be considered only provisional.

[? SPIROPTERA] TENUICAUDA MOLIN, 1860.

(Fig. 31.)

SYNONYMY AND BIBLIOGRAPHY.

1860: *Spiroptera tenuicauda* MOLIN, 1860, pp. 983-984, 991, 992.—LINSTOW, 1878, pp. 124, 145.—IDEM, 1889, p. 58.—DRASCHE, 1884a, p. 207, pl. 12, fig. 17.—STOSSICH, 1897, pp. 88-89, 149.
 1860: *Spiroptera ciconiæ maguari* MOLIN, 1860, p. 983 [as synonym of *Spiroptera tenuicauda*; not *S. ciconiæ maguari* Molin, 1860, p. 982—*S. excisa*; not *S. ciconiæ maguari* Molin, 1860, p. 486 = *Dispharagus longevagatus*].
 1860: *Spiroptera cracis* N. of MOLIN, 1860, p. 983 [as synonym of *S. tenuicauda*; not *S. cracis* Molin, 1860, p. 944—*S. heteroclita*].

SPECIFIC DIAGNOSIS.—? *Spiroptera*:

Male: Unknown.

Female: 8 to 19 mm. long by 0.2 mm. thick. Body slender, increasing in thickness anteriorly, posteriorly gradually attenuated. Anterior end coiled in a single turn, apex truncated. Head with two membranous alæ,^a lips absent, mouth opening hexagonal, two lateral and four submedian papillæ. Pharynx absent.* Esophagus ends in a bulb with dental apparatus. Tail straight, slender, acutely conical, with very acute tip. Anus remote from caudal tip. Position of vulva not determined.

HABITAT.—*Ciconia maguari* [= South American stork, *Euxenura maguari*]; proventriculus; Brazil (Molin, 1860).—*Crax tomentosa* [= Brazilian mitua, *Mitua tomentosa*]; under nictitating membrane; Brazil (Molin, 1860).

TYPE SPECIMENS.—In Vienna Museum.

This species is based on specimens of two females collected by Natterer in 1831 from the proventriculus of *Ciconia maguari*, and two females and a fragment from under the nictitating membrane of *Crax tomentosa*, also collected by Natterer in 1831. Molin (1860, p. 984), considers it probable that the forms from *Ciconia* are of a different species from those from *Crax*, but since he saw no males from either

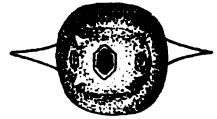


FIG. 31.—[? *Spiroptera*] *tenuicauda*. Anterior view of head. $\times 280$. (Haines del., after Drasche, 1884a, pl. 12, fig. 17.)

^a According to Molin (1860, p. 983), membranous appendages are lacking. Drasche (1884a, p. 20), who reexamined Molin's material, found alæ on the head.

host, the great similarity in the females did not justify him, he believed, in creating two species.

Drasche (1884a, p. 207), who reexamined the original material, does not state whether he examined specimens from both hosts or from but one. He doubts that the species belongs in the genus *Spiroptera*.

GENUS *APROCTA* LINSTOW, 1883.

GENERIC DIAGNOSIS.—Filariidæ: Body rounded at both ends. Head attenuated. Mouth without lips. Esophagus short. Anus lacking. Lateral fields very broad and thin, without excretory vessels. Excretory pore lacking. Caudal extremity without papillæ, or with a single unpaired papilla near posterior end.

TYPE SPECIES.—*Aprocta cylindrica* Linstow, 1883.

APROCTA CYLINDRICA LINSTOW, 1883.

(Fig. 32.)

SYNONYMY AND BIBLIOGRAPHY.

1883: *Aprocta cylindrica* LINSTOW, 1883, pp. 289-290, pl. 7, fig. 21.—IDEM, 1889, p. 35.—IDEM, 1901, p. 188.

SPECIFIC DIAGNOSIS.—*Aprocta*: Head rounded without lips or papillæ. Tail rounded in both sexes. Esophagus short; measures $\frac{1}{5}$ of the length of the body. Anus absent. Musculature meromyarian. Lateral fields very broad and thin.

Male: 16 mm. long by 0.54 mm. thick. Genital opening prominent; one pair postanal papillæ. Tip of tail prolonged into short appendage. Spicules two, almost equal, short, curved, 0.31 mm. and 0.28 mm. in length.

Female: 27 mm. long by 0.9 mm. wide. Eggs elliptical, 0.026 by 0.01 mm.

HABITAT.—*Petroca cyanea* [=blue rock thrush, *Petrophila cyaneus*]; orbital cavity; Turkestan (Linstow, 1883).

TYPE SPECIMENS.—[?].

APROCTA OPHTHALMOPHAGA STOSSICH, 1902.

SYNONYMY AND BIBLIOGRAPHY.

1902: *Aprocta ophthalmophaga* STOSSICH, 1902, p. 73.

SPECIFIC DIAGNOSIS.—*Aprocta*: Body thick, cylindrical, attenuated at both ends. Head (lacking in all specimens studied).

Male: 20 to 24 mm. long. Tail coiled spirally, with rounded tip, lacking bursa and papillæ. Cloacal opening salient; spicules two, of equal length, short, with hook-like points.

Female: 40 mm. long. Caudal extremity broad and rounded. Vulva prominent near cephalic extremity. Eggs elliptical, with thick yellowish shell.

HABITAT.—Falcon, *Falco* sp.; behind eyeball; Abyssinia (Stossich, 1902).

TYPE SPECIMENS.—In Collection Parona.

This species is based upon a number of specimens collected by Doctor Traverso in November, 1885.



FIG. 32.—*Aprocta cylindrica*. Posterior end of male. Enlarged. (Haines del., after Linstow, 1883, pl. 7, fig. 21.)

APROCTA ORBITALIS LINSTOW, 1901.

(Figs. 33, 34.)

SYNONYMY AND BIBLIOGRAPHY.

1901: *Aprocta orbitalis* LINSTOW, 1901, p. 188, pl. 8, figs. 10, 11.

SPECIFIC DIAGNOSIS.—*Aprocta*: Anterior end of body rounded, somewhat conical, without papillæ. Esophagus short, anus absent, lateral fields very thin and broad, each equal to $\frac{1}{2}$ of the periphery of the body. Excretory vessels and pore lacking.

Male: 21 mm. long by 1.03 mm. thick. Esophagus $\frac{1}{5}$ the body length. Tail coiled into a double spiral. Tip prolonged into a short appendage with rounded extremity. Appendage measures $\frac{1}{7}$ of the body length. Spicules two, short, 0.40 and 0.47 mm. in length. Genital opening rather prominent. Papillæ absent.

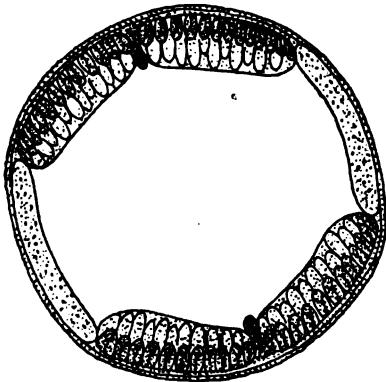


FIG. 33.—*Aprocta orbitalis*. Cross section. Enlarged. (Haines del., after Linstow, 1901, pl. 8, fig. 10.)

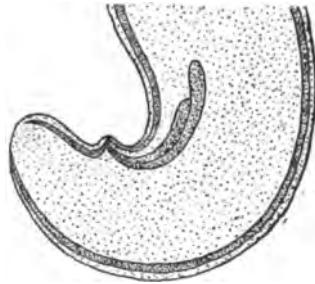


FIG. 34.—*Aprocta orbitalis*. Posterior end of male. Enlarged. (Haines del., after Linstow, 1901, pl. 8, fig. 11.)

Female: 38 mm. long by 1.26 mm. thick. Esophagus $\frac{1}{3}$ of the body length. Vulva rather prominent, anterior, 0.79 to 1.03 mm. from the cephalic extremity. Eggs thick-shelled, oldest contain worm-like embryos and measure 0.055 mm. long by 0.036 mm. thick.

HABITAT.—*Falco fuscoater* [=black kite, *Milvus korschun*]; orbit; ? locality (Linstow, 1901).

TYPE SPECIMENS.—In Breslau Collection.

GENUS **PHYSALOPTERA** RUDOLPHI, 1819.

GENERIC DIAGNOSIS.—Filaridiæ: Mouth with two equal lips, each with three papillæ on the outer surface, and each armed with teeth at the extremity and usually also on the internal surface. There are usually present cuticular expansions of variable form behind the lips. Posterior extremity of male is lanceolate, spoon-like, surrounded by a vesicular border. Two varieties of papillæ: A series of external pedunculate papillæ, four on each side, in the anal region, serving as supporting ribs for the bursa; and internal papillæ, almost always sessile; frequently an unpaired papilla in front of the anus. Spicules two, unequal. Female with two ovaries; vulva in anterior part of body. Oviparous.

TYPE SPECIES.—*Physaloptera clausa* Rudolphi, 1819.^a

^aSee nematode check-list by Stiles & Hassall (MS.).

PHYSALOPTERA ACUTICAUDA MOLIN, 1860.

(Figs. 35, 36.)

SYNONYMY AND BIBLIOGRAPHY.

1851: *Physaloptera alata* RUDOLPHI of DIESING, 1851a, p. 234 [in part].—MOLIN, 1860, p. 661 [in part; as synonym of *P. acuticauda*].

1860: *Physaloptera acuticauda* MOLIN, 1860, pp. 661-663, 669, 670.—LINSTOW, 1878, pp. 110, 114, 115, 116, 117, 118.—IDEM, 1889, p. 41.—IDEM, 1901, p. 413.—DRASCHE, 1883b, p. 127, pl. 8, figs. 4, 5.—STOSSICH, 1889, pp. 46, 56, pl. 2, fig. 14, pl. 3, fig. 33.

SPECIFIC DIAGNOSIS.—*Physaloptera*: Body filiform, more attenuated posteriorly.

Well-developed membranous expansions on the head. Mouth bilabiate, anterior border of lips semicircular. Each lip furnished with a large pointed outer tooth and three small inner teeth.

Male: 20 to 32 mm. long by 0.8 mm. thick. Tail curved, with long semilanceolate bursal membranes; four pairs of rib-like papillæ supporting the bursal membrane on either side, two postanal and two preanal; near the median line five pairs of sessile postanal papillæ, two just posterior of the anal opening, two slightly farther back, and the remaining pair at about two-thirds of the distance from the anus to the tip of the tail; one pair of preanal papillæ not far from the median line a short distance in front of the anus, and a single median unpaired papilla just anterior of the anal opening; spicules two, unequal, one of them very long and filiform.

Female: 20 to 43 mm. long by 0.8 to 1.2 mm. thick. Tail long and conical, with rather acute tip. Anus some distance from tip of tail. Vulva in anterior part of body.

HABITAT.—Falcon, *Falco* sp.; gizzard.—*Falco cachinnans* [=laughing falcon, *Herpetotheres cachinnans*]; esophagus and gizzard.—*Falco gracilis* [=gray crane-hawk, *Geranospizias cerulescens*]; esophagus and gizzard.—*Falco swainsonii* [=Vigors hawk, *Gampsonyx swainsoni*]; esophagus.—*Falco rutilans* [=brown buzzard, *Heterospizias meridionalis*]; gizzard.—*Falco ornatus* [=Brazilian crested eagle, *Spizaetus mauudyti*]; esophagus and gizzard.—*Falco palustris* [=long-winged harrier, *Circus maculosus*]; esophagus and gizzard.—*Falco coronatus* [=crowned harpy, *Harpyhaliaetus coronatus*]; orbital cavity, free in occipital region and in gizzard.—*Falco urubitinga* [=South American black hawk, *Urubitinga urubitinga*]; gizzard.—*Falco dispar* [=long-tailed kite, *Elanus leucurus*]; gizzard.—*Falco atricapillus* [=Vieillot hawk, *Spizaister melanoleucus*]; mouth, esophagus, and gizzard.—*Falco cayennensis* [=Cayenne falcon, *Leptodon cayennensis*]; gizzard.—*Falco unicinctus* [=one banded buzzard, *Parabuteo unicinctus*]; esophagus and gizzard.—*Falco minutus* [=South American sharp-shinned hawk, *Accipiter tinus*]; gizzard. All the above hosts were first reported by Molin (1860) from Brazil.—Black-winged kite, *Elanus caruleus*; stomach; Lake Nyassa, Africa (Linstow, 1901).

TYPE SPECIMENS.—In Vienna Museum.

Drasche (1883b) has restudied the original material.

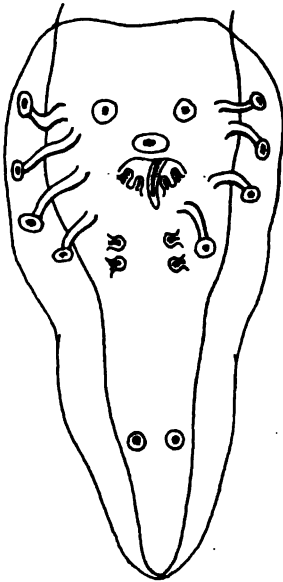


FIG. 35.—*Physaloptera acuticauda*. Posterior end of male. $\times 80$. (Haines del., after Drasche, 1883b, pl. 8, fig. 4.)



FIG. 36.—*Physaloptera acuticauda*. Inner view of lip. $\times 165$. (Haines del., after Drasche, 1883b, pl. 8, fig. 5.)

PHYSALOPTERA SP. PARONA, 1885.

(Fig. 37.)

SYNONYMY AND BIBLIOGRAPHY.

1885: *Physaloptera* sp. PARONA, 1885, pp. 438-439, pl. 7, fig. 22.—
LINSTOW, 1889, p. 53.

SPECIFIC DIAGNOSIS.—*Physaloptera*:

Male: Unknown.

Female: 32 mm. long. Head with wing-like appendages and two or more papillæ or lips.

HABITAT.—Sacred ibis, *Ibis aethiopica*; orbital cavity; Abyssinia (Parona, 1885).

TYPE SPECIMENS.—[?]

One specimen collected by P. Magretti in March, 1882.

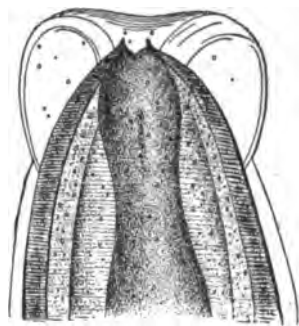


FIG. 37.—*Physaloptera* sp. Anterior end of female, showing wing-like appendages and lips. $\times 75$. (Haines del., after Parona, 1885, pl. 7, fig. 22.)

GENUS SYNGAMUS SIEBOLD, 1836.

GENERIC DIAGNOSIS.—Strongylidæ: Head thick. Mouth large, followed by a chitinous pharyngeal capsule.

Male: Truncated posteriorly with fan-like bursa and two spicules.

Female: With a double ovary. Vulva usually anterior of the middle of the body. Copulation is permanent in many species.

HABITAT.—Usual habitat is the trachea and bronchi of birds and mammals.

TYPE SPECIES.—*Syngamus trachealis* Siebold, 1836.

SYNGAMUS LARI (BLANCHARD, 1849) STOSSICH, 1899.

(Figs. 38-40.)

SYNONYMY AND BIBLIOGRAPHY.

- 1829: *Nematoideum lari ridibundi* CREPLIN, 1829b, p. 36.—IDEM [1846a, p. 140].—DIESING, 1851a, p. 321 [as synonym of *Strongylus lari ridibundi*].—LINSTOW, 1878, p. 168.
- 1837: *Strongylus* sp. SIEBOLD, 1837, p. 68.—CREPLIN, 1851b, p. 239 [= *Nematoideum lari ridibundi* Creplin, 1829 = *Cyathostoma lari* Blanchard, 1849].
- 1849: *Cyathostoma lari* BLANCHARD, 1849a, pp. 183-185, pl. 7, fig. 5.—IDEM in CUVIER [? date] (zoophytes), pl. 25, figs. 6, 6a, 6b.—DIESING, 1851a, p. 306 [as synonym of *Sclerostomum cyathostomum*].—IDEM, 1861a, p. 717 [as synonym of *Sclerostomum cyathostomum*].—GERVAIS & VAN BENEDEN, 1859b, p. 106.—MOLIN, 1861, p. 561 [as synonym of *Sclerostomum lari* Molin].—RAILLIET, 1898, p. 402.—STOSSICH, 1899, p. 100 [as synonym of *Syngamus lari*].
- 1851: *Sclerostomum cyathostomum* DIESING, 1851a, pp. 306-307.—IDEM, 1861a, pp. 717-718.—MOLIN, 1861, p. 561 [as synonym of *Sclerostomum lari* Molin].—LINSTOW, 1878, p. 167.—PARONA, 1894, p. 235.—MÜHLING, 1898, p. 48.—STOSSICH, 1899, p. 100 [as synonym of *Syngamus lari*].
- 1851: *Strongylus lari ridibundi* DIESING, 1851a, p. 321.—IDEM, 1861a, p. 718 [as probable synonym of *Sclerostomum cyathostomum*].—MÜHLING, 1898, p. 48 [as synonym of *Sclerostomum cyathostomum*].
- 1861: *Sclerostomum lari* (Blanchard, 1849) MOLIN, 1861, p. 561.—STOSSICH, 1899, p. 100 [as synonym of *Syngamus lari*].
- 1899: *Syngamus lari* (Blanchard, 1849) STOSSICH, 1899, pp. 100-101.

SPECIFIC DIAGNOSIS.—*Syngamus*: Body, red in color, attenuated anteriorly. Mouth opens into a pharyngeal capsule, which is marked in front by an annulation. Esophagus is thick and muscular, and increases gradually in diameter posteriorly. Intestine rather sinuous, with thin delicate walls, dark in color.

Male: 6 to 8 mm. long (Siebold, 1837, p. 68). Body ends abruptly behind; membranous fan-like bursa with six rays, of which the middle ones are the most marked; two spicules of equal length. Testicle a single very wide tube sinuous anteriorly.

Female: 6 to 8 mm. long (Creplin, 1829b, p. 36); 10 mm. long by 0.5 to 0.7 mm. thick (Siebold, 1837, p. 68); 10 to 13 mm. long by about 1 mm. thick (Blanchard, 1849a, p. 183). Body becomes gradually thicker in the anterior third, then continues of equal thickness to the posterior extremity. Tail with slender conical tip. Cuticula finely striated. Esophagus equals about one-fifteenth of the length of the body. Ovaries two, widening into capacious uteri, which unite to form a vagina of about 2 mm. in length. The latter gradually decrease in diameter toward the vulva, a large prominent opening, with salient lips, situated slightly posterior of the middle of the body.

HABITAT.—Black-headed gull, *Larus ridibundus*; nasal cavity; ? Europe (Creplin, 1829); orbital cavity; Sicily (Blanchard, 1849).—Lesser black-backed gull, *Larus fuscus*; infra-orbital cells; ? Europe (Siebold, 1837).—Gulls, *Larus* sp.; nasal fossae; Belgium (Gervais & Van Beneden, 1859).

TYPE SPECIMENS.—[?]

Creplin (1829, p. 36) is the first to mention this form, reporting the discovery of a single female, found by Schilling in 1826 in the nasal cavity of *Larus ridibundus*.



FIG. 38.—*Syngamus lari*. Female. Enlarged about 12 times. (Haines del., after Blanchard, in Cuvier [? date] (zoophytes), pl. 25, fig. 6 a.)



FIG. 39.—*Syngamus lari*. Anterior end of female. Much enlarged. (Haines del., after Blanchard, in Cuvier [? date] (zoophytes), pl. 25, fig. 6 a.)



FIG. 40.—*Syngamus lari*. Vulva. Enlarged. (Haines del., after Blanchard, in Cuvier [? date] (zoophytes), pl. 25, fig. 6 b.)

Siebold (1837, p. 68) reported a number of males and females found by him in the infraorbital cells of *Larus fuscus*. Blanchard (1849a, p. 183) collected five females from the orbit of *Larus ridibundus* and gives a

description of the female. Gervais & Van Beneden (1859b, p. 106) found three females and two males in the nasal fossæ of birds of the genus *Larus* from Belgium, and gave a short description of the male.

? GENUS **ASCARIS.**

ASCARIS LEPTOPTERA RUDOLPHI OF RAYER, 1843; NOT RUDOLPHI, 1810.

Rayer (1843, pp. 146, 148, 149, pl. 4, figs. 7-10) mentions and figures a worm from beneath the palpebral conjunctiva of *Emberiza pecoris* [= *Molothrus ater*], which he identifies as *Ascaris leptoptera*, a species described by Rudolphi from the esophagus and stomach of a lion. No description is given, and the figures are not sufficiently distinctive to enable one to identify the form in question. From the figures, the head is seen to possess lateral alæ, and the tail has a slender acutely pointed tip. Most authors have referred this form provisionally to *Spiroptera leptoptera* Rudolphi, 1819, a parasite of falcons, but such an arrangement seems hardly warranted by the facts in the case.

COMPENDIUM OF NEMATODES PARASITIC IN THE EYES OF BIRDS ARRANGED ACCORDING TO HOSTS.

I am much indebted to Mr. H. C. Oberholser of the Biological Survey, U. S. Department of Agriculture, for his generous assistance in determining the present-used scientific and common names of the hosts here listed, and arranging them into orders and families.

The star (*) signifies that the parasite so indicated has been reported from the eye of the host with which it is listed.

ORDER CRYPTURIFORMES.

Family TINAMIDÆ.

Crypturus variegatus (Latham). Variegated tinamou.

* [*? Filaria*] *tinami variegati*, p. 38.

ORDER CICONIIFORMES.

Family CICONIIDÆ.

Euxenura maguari (Temminck). South American stork.

[*? Spiroptera*] *tenuicauda*, p. 39.

Family IBIDIDÆ.

Ibis æthiopica (Latham). Sacred ibis.

* *Physaloptera* sp., p. 43.

ORDER FALCONIFORMES.

Family FALCONIDÆ.

Accipiter tinus (Latham). South American sharp-shinned hawk.

Physaloptera acuticauda, p. 42.

Aquila maculata (Gmelin). Spotted eagle.

* [*? Oxyrspirura*] *stereura*, p. 29.

* [*? Filaria abbreviata*], p. 31.

Archibuteo lagopus (Gmelin). Rough-legged hawk.

*[? *Filaria*] *armata*, p. 33.

Circus maculosus (Vieillot). Long-winged harrier.

Physaloptera acuticauda, p. 42.

Elanus caeruleus (Desfontaines). Black-winged kite.

Physaloptera acuticauda, p. 42.

Elanus leucurus (Vieillot). White-tailed kite.

Physaloptera acuticauda, p. 42.

Falco sp. Falcon.

* *Aprocta ophthalmophaga*, p. 40.

Falco sp. Falcon.

Physaloptera acuticauda, p. 42.

Gampsonyx swainsoni (Vigors). Vigors hawk.

* *Filaria papilloso-annulata*, p. 37.

Physaloptera acuticauda, p. 42.

Geranospizias carulescens (Vieillot). Gray crane-hawk.

*[? *Oryspirura*] *papillosa*, p. 27.

Physaloptera acuticauda, p. 42.

Harpyhaliaetus coronatus (Vieillot). Crowned harpy.

* *Physaloptera acuticauda*, p. 42.

Heterospizias meridionalis (Latham). Brown buzzard.

Physaloptera acuticauda, p. 42.

Leptodon cayennensis (Gmelin). Cayenne falcon.

Physaloptera acuticauda, p. 42.

Milvus korschun (Gmelin). Black kite.

* *Aprocta orbitalis*, p. 41.

Parabuteo unicinctus (Temminck). One-banded buzzard.

Physaloptera acuticauda, p. 42.

Rupornis magnirostris (Gmelin). Large-billed hawk.

* [? *Filaria*] *campanulata*, p. 34.

Spizaetus mauduyti (Daudin). Brazilian crested eagle.

Physaloptera acuticauda, p. 42.

Spizias ter melanoleucus (Vieillot). Vieillot hawk.

Physaloptera acuticauda, p. 42.

Thrasaetus harpyia (Linnæus). Harpy eagle.

* [? *Oryspirura*] *papillosa*, p. 27.

Urubitinga urubitinga (Gmelin). South American black hawk.

Physaloptera acuticauda, p. 42.

ORDER GALLIFORMES.

Family TURNICIDÆ.

Turnix taigoo (Sykes). Indian bustard-quail.

* *Oxyrura ophthalmica*, p. 26.

Family CRACIDÆ.

Crax fasciolata (Spix). Spix curassow.

* [? *Oxyrura*] *anolabiata*, p. 21.

Mitua tomentosa (Spix). Brazilian mitua.

* [? *Spiroptera*] *tenuicauda*, p. 39.

Nothocrax urumutum (Spix). Urumutu.

* [? *Oxyrura*] *heterochila*, p. 24.

Family PHASIANIDÆ.

Gallus domesticus. Chicken.

* *Oxyspirura Mansoni*, pp. 7-20, 25.

Pavo cristatus (Linnæus). Peafowl.

* *Oxyspirura Mansoni*, pp. 7-20, 25.

Family TETRAONIDÆ.

Odontophorus stellatus (Gould). Stellated partridge.

Filaria obtusocaudata, p. 35.

Tetrastes bonasia (Linnæus). Hazel hen.

* [*Filaria*] *bonasie*, p. 33.

ORDER GRUIFORMES.

Family CARIAMIDÆ.

Cariama cristata (Linnæus). Seriema.

* [*Oxyspirura*] *brevipennis*, p. 22.

ORDER CHARADRIIFORMES.

Family LARIDÆ.

Larus fuscus Linnæus. Lesser black-backed gull.

Syngamus lari, p. 43.

Larus ridibundus Linnæus. Black-headed gull.

* *Syngamus lari*, p. 43.

Larus spp. Gulls.

Syngamus lari, p. 43.

Family TRERONIDÆ.

Zonanas brenchleyi (Gray). Brenchley fruit pigeon.

* *Ceratospira ophthalmica*, p. 30.

ORDER CUCULIFORMES.

Family CUCULIDÆ.

Centropus sinensis (Stephens). Indian ground cuckoo.

* *Oxyspirura siamensis*, p. 28.

Crotophaga ani (Linnæus). Common smooth-billed ani.

* *Oxyspirura anacanthura*, p. 21.

Crotophaga major (Gmelin). Greater ani.

* *Oxyspirura anacanthura*, p. 21.

Family PSITTACIDÆ.

Eclectus pectoralis (Müller). Red-sided eclectus.

* *Ceratospira vesiculosa*, p. 30.

? Genus. ? Species. Parrot.

* *Filaria oculi*, p. 37.

ORDER CORACIIFORMES.

Family PICIDÆ.

Campephilus robustus (Lichtenstein). Brazilian ivory-billed woodpecker.

Filaria obtusocaudata, p. 35.

Campephilus rubricollis (Boddaert). Red-necked ivory-billed woodpecker.

Filaria obtusocaudata, p. 35.

Celeus flavescens (Gmelin). Black and yellow woodpecker.

Filaria obtusocaudata, p. 35.

Celeus jumana (Spix). Jumana woodpecker.

Filaria obtusocaudata, p. 35.

Ceophlæus lineatus (Linnæus). Lineated woodpecker.

Filaria obtusocaudata, p. 35.

Chloronerpes aurulentus (Temminck). Brazilian green woodpecker.

Filaria obtusocaudata, p. 35.

Chloronerpes leucolamæus (Malherbe). White-throated green woodpecker.

Filaria obtusocaudata, p. 35.

Veniliornis passerinus (Linnæus). Sparrow woodpecker.

* *Filaria obtusocaudata*, p. 35.

FAMILY MOMOTIDÆ.

Momotus momota (Linnæus). Motmot.

* *Oxyrura cephaloptera*, p. 23.

FAMILY STRIGIDÆ.

Ninox scutulata (Raffles). Burmese hawk owl.

* [? *Spiroptera*] Feai, p. 39.

Otus choliba (Vieillot). Brazilian screech owl.

* *Oxyrura brevisubulata*, p. 23.

FAMILY ASIONIDÆ.

Asio (= *Bubo* sp.) Eagle owl.

*? *Filaria attenuata*, p. 33.

FAMILY CAPRIMULGIDÆ.

Caprimulgus europæus Linnæus, or *C. ægyptius* Lichtenstein. Nightjar.

*? *Spiroptera caprimulgi*, p. 38.

ORDER PASSERIFORMES.

FAMILY DENDROCOLAPTIDÆ.

Xiphorhynchus procurrens (Temminck). Curve-bill woodhewer.

* [? *Filaria*] *dendrocolaptis procurvi lacrymalis*, p. 35.

FAMILY FURNARIIDÆ.

Furnarius leucopus Swainson. Pale-footed oven-bird.

Filaria abbreviata, p. 31.

Furnarius rufus (Gmelin). Red oven-bird.

Filaria abbreviata, p. 31.

FAMILY FORMICARIIDÆ.

Chamaeza brevicauda (Vieillot). Short-tailed ant-thrush.

* [? *Filaria*] *myotheræ companionæ*, p. 35.

? FAMILY TYRANNIDÆ.

Muscicapa sp. [= ? genus. ? species.]

? *Filaria abbreviata*, p. 31.

Family TURDIDÆ.

- Aedon tuscina* (Linnæus). Thrush nightingale.
 ? *Filaria abbreviata*, p. 31.
Erithacus rubecula (Linnæus). Robin redbreast.
Filaria abbreviata, p. 31.
Petrophila cyanus Linnæus. Blue rock-thrush.
 * *Aprocta cylindrica*, p. 40.
Saxicola cenanthe (Linnæus). Wheatear.
 ? *Filaria abbreviata*, p. 31.
Saxicola rufa (Stephens). Russet wheatear.
 * *Filaria abbreviata*, p. 31.
Saxicola sp.
 ? *Filaria abbreviata*, p. 31.
Turdus olivascens (doubtful form; name not found in ornithological literature).
 * [? *Filaria*] *turdi olivascensis palpebralis*, p. 38.
Turdus pilaris Linnæus. Fieldfare.
 ? *Filaria abbreviata*, p. 31.
Turdus viscivorus Linnæus. Mistletoe thrush.
 ? *Filaria abbreviata*, p. 31.

Family SYLVIIDÆ.

- Melizophilus melanocephalus* (Gmelin). Sardinian warbler.
Filaria abbreviata, p. 31.
Phylloscopus minor (Forster). Chiffchaff.
 * [? *Filaria*] *sylvia*, p. 37.

Family TROGLODYTIDÆ.

- Cistothorus polyglottus* (Vieillot). Brazilian short-billed marsh wren.
Filaria abbreviata, p. 31.

Family CORVIDÆ.

- Corvus corone* Linnæus. Black crow.
 * ? *Filaria attenuata*, p. 33.
Corvus frugilegus Linnæus. Rook.
 * *Oxyspirura sygmoidea*, p. 29.

Family LANIIDÆ.

- Lanius minor* Gmelin. Lesser gray shrike.
Filaria obtusocaudata, p. 35.
Lanius senator Linnæus. Pomerine shrike.
Filaria obtusocaudata, p. 35.
Lanius rutilus Latham. Rufous shrike.
Filaria obtusocaudata, p. 35.
Lanius sp.
Filaria obtusocaudata, p. 35.
Lanius sp.
 ? *Filaria obtusocaudata*, p. 35.

Family MOTACILLIDÆ.

- Motacilla alba* Linnæus. White wagtail.
 ? *Filaria abbreviata*, p. 31.

Family ICTERIDÆ.

- Amblyramphus holosericeus* (Scopoli). Scarlet-headed marsh-bird.
Filaria abbreviata, p. 31.

Icterus croconotus Gray. Orange-backed troupial.

**Oryzopsis cephaloptera*, p. 23.

Megaquiscalus major (Vieillot). Boat-tailed grackle.

**Filaria cirrura*, p. 34.

Molothrus ater (Boddaert). Cowbird.

**Ascaris leptoptera* of Rayer, p. 45.

FAMILY TANAGRIDÆ.

Ramphocelus jacapa (Linnaeus). Jacapa tanager.

Filaria abbreviata, p. 31.

BIBLIOGRAPHY.

[The references may be consulted at the Governmental libraries in Washington, D. C., as designated: W^c = Library of the United States Department of Agriculture. W^s = Library of Congress. W^m = Library of the Surgeon-General's Office. Wⁿ = Library of the Smithsonian Institution.]

ALESSANDRINI, ANTONIO.

1838.—Osservazioni anatomiche intorno a diverse specie di entozoarii del genere *Filaria* <N. Ann. d. sc. nat., Bologna, v. 1, pp. 1-17, pl. 1, figs. 1-12. [W^c.]

BLANCHARD, ÉMILE.

1849 a.—Recherches sur l'organisation des vers <Ann. d. sc. nat., Par., Zool., 3. s., v. 11, fév.-août, pp. 106-202, pls. 6-8; v. 12, juillet-août, pp. 5-68, 1 chart. [W^a.]

CORBOLD, THOMAS SPENCER.

1879 b.—Parasites; a treatise on the entozoa of man and animals, including some account of the ectozoa. xi+508 pp., 85 figs. 8°. London. [W^a.]

1880 k.—[Prefatory note to "Further observations on microfilariae, with descriptions of a new species," by P. Manson] <J. Quekett Micr. Club, Lond. (44), v. 6, Aug., pp. 130-132. [W^m.]

CREPLIN, FRID[RICH] CHRIST[IAN] HENR[ICH].

1829 b.—Novæ observationes de entozois. iv+134 pp., 1 l., 2 pls., 20 figs. 8°. Berolini. [W^a.]

1846 a.—Nachträge zu Gurlt's Verzeichniss der Thiere, bei welchen Entozoen gefunden worden sind <Arch. f. Naturg., Berl., 12. J., v. 1, pp. 129-160. [W^a.]

1846 b.—*Filaria* <Allg. Encycl. d. Wissensch. u. Künste (Ersch & Gruber), Leipz., 1. sect., v. 44, pp. 154-178. [W^c.]

1851 b.—Nachträge von Creplin zu Gurlt's Verzeichniss der Thiere, in welchen Entozoen gefunden worden sind. Vierter Nachtrag <Arch. f. Naturg., Berl., 17. J., v. 1, pp. 269-310. [W^a.]

CUVIER, G[EOGES-LÉOPOLD-CHRÉTIEN-FRÉDÉRIC-DAGOBERT].

[?].—Le règne animal distribué d'après son organisation, pour servir de base à l'histoire naturelle des animaux, et d'introduction à l'anatomie comparée. Édition accompagnée de planches gravées représentant les types de tous les genres, les caractères distinctifs des divers groupes et les modifications de structure sur lesquelles repose cette classification par une réunion de disciples de Cuvier, Audouin, Blanchard, Deshayes, Alcide D'Orbigny, Doyère, Dugès, Duvernoy, Laurillard, Milne-Edwards, Roulin et Valenciennes. [Les zoophytes.] 160+94 pp., 97. pls. 4°. Paris. [W^a, W^m.]

DIESING, KARL MORITZ.

1851 a.—*Systema helminthum*. v. 2, vi+588 pp., 21. 8°. Vindobonæ. [W^m.]

1861 a.—Revision der Nematoden <Sitzungsb. d. k. Akad. d. Wissensch., Wien, Math.-naturw. Cl. (1860), v. 42 (28), 6. Dec., pp. 595-736, 1 pl., figs. 1-11. [W^a.]

VON DRASCHE, RICHARD.

1883 b.—Revision der in der Nematoden-Sammlung des k. k. zoologischen Hofcabinetes befindlichen Original-Exemplare Diesing's und Molin's <Verhandl. d. k. k. zool.-bot. Gesellsch. in Wien (1882), v. 32, pp. 117-138, pls. 7-10. [W^a.]

1884 a.—Idem [continued] <Ibidem (1883), v. 33, pp. 107-118, pls. 3-5 [read 7. Feb. 1883]; pp. 193-218, pls. 11-14 [read 4. Apr. 1883]. [W^a.]

DUJARDIN, FÉLIX.

1845 a.—*Histoire naturelle des helminthes, ou vers intestinaux*. xvi+654+15 pp., 12 pls. 8°. Paris. [W^a, W^m.]

EMMEREZ DE CHARMOY; & MÉGNIN, PIERRE.

1901 a.—Un nouveau parasite et une nouvelle maladie chez les poulets de l'île Maurice <Compt. rend. Soc. de biol., Par., v. 53 (33), 8 nov., pp. 933-935, figs. A-E. [W^a, W^m.]

GEDOELST, L.

1903 a.—Résumé du cours de parasitologie. ix+107 pp. 8°. Bruxelles. [Lib. Stiles.]

GERVAIS, PAUL; & VAN BENEDEN, PIERRE-JOSEPH.

1859 b.—*Zoologie médicale*. Exposé méthodique du règne animal, basé sur l'anatomie, l'embryogénie et la paléontologie; comprenant la description des espèces employées en médecine, de celles qui sont venimeuses et de celles qui sont parasites de l'homme et des animaux. v. 2, viii+455 pp., figs. 98-198. 8°. Paris. [W^m, W^a, Lib. Stiles.]

GESCHEIDT, [LUDOVICUS] ANTONIUS.

1833 a.—Die Entozoen des Auges. Eine naturhistorische, ophthalmosologische Skizze <Ztschr. f. d. Ophth., Dresd., v. 3 (4), pp. 405-462. [W^m.]

1834 a.—Ueber die Entozoen des Auges. [Review of Gescheidt, 1833 a] <Notiz. a. d. Geb. d. Nat.- u. Heilk., Weimar (840), v. 39 (4), Jan., pp. 52-55. [W^m.]

GURLT, E[RNST] F[RIEDRICH].

1845 a.—Verzeichniss der Thiere, bei welchen Entozoen gefunden worden sind <Arch. f. Naturg., Berl., 11. J., v. 1, pp. 223-325; 330-336. [W^a.]

LEIDY, JOSEPH.

1886.—Notices of nematoid worms <Proc. Acad. Nat. Sc., Phila. [3. s., v. 16] (3), Oct., pp. 308-313, 1 fig. [pp. 308-312 published Oct. 12; p. 313 published Oct. 26.] [W^a, W^a.]

LEUCKART, RUDOLF.

1876.—Die menschlichen Parasiten und die von ihnen herrührenden Krankheiten. Ein Hand- und Lehrbuch für Naturforscher und Aerzte. v. 2, Lief. 3, pp. 513-882, figs. 283-401. 8°. Leipzig & Heidelberg. [W^a.]

VON LINSTOW, OTTO.

1878.—Compendium der Helminthologie. Ein Verzeichniss der bekannten Helminthen, die frei oder in thierischen Körpern leben, geordnet nach ihren Woonthieren, unter Angabe der Organe, in denen sie gefunden sind, und mit Beifügung der Litteraturquellen. xxii+382 pp. 8°. Hannover. [Published May 16.] [W^a, Lib. Stiles.]

- 1879.—*Helminthologische Untersuchungen* <Jahresh. d. Ver. f. vaterl. Naturk. in Württemb., Stuttg., v. 35, pp. 313–342, pl. 5, figs. 1–24. [W^c.]
- 1883.—*Nematoden, Trematoden und Acanthocephalen, gesammelt von Prof. Fedtschenko in Turkestan* <Arch. f. Naturg., Berl., 49, J., v. 1 (2), pp. 274–314, pls. 6–9, figs. 1–52. [W^a.]
- 1886.—[*Nematodes, trematodes, and acanthocephala collected by Fedtschenko in Turkestan.*] [Russian text] <Izviest. Imp. Obsh. Liub., Estestvozn., Antrop., Moskva, v. 34 (3), 40 pp., 55 figs. (Fedtschenko. Travels in Turkestan. Pt. 18, v. 2, Zoogeographical Survey (5).) [W^a.]
- 1889.—*Compendium der Helminthologie. Nachtrag. Die Litteratur der Jahre 1878–1889.* xvi+151 pp. 8°. Hannover. [W^a, Lib. Stiles.]
- 1898.—*Nemathelminthen gesammelt von Herrn Prof. Dr. F. Dahl im Bismarck-Archipel* <Arch. f. Naturg., Berl. (1897), 63. J., v. 1 (3), März, pp. 281–291, pls. 21–22, figs. 1–21. [W^a, W^a.]
- 1901.—*Beobachtungen an Helminthen des Senkenbergischen naturhistorischen Museums, des Breslauer Zoologischen Instituts und anderen* <Arch. f. mikr. Anat., Bonn, v. 58 (1), 25. Mai, pp. 182–198, pls. 8–9, figs. 1–30. [W^m.]
- 1901.—*Helminthen von den Ufern des Nyassa-Sees, ein Beitrag zur Helminthen-Fauna von Süd-Afrika* <Jenaische Ztschr. f. Naturw., Jena, v. 35, n. F., v. 28 (4), 20. Apr., pp. 409–428, pls. 13–14, figs. 1–34, A–E. [W^c, W^m.]
- 1903.—*Parasiten, meistens Helminthen, aus Siam* <Arch. f. mikr. Anat., Bonn, v. 62 (1), pp. 108–121, pl. 5, figs. 1–23. [Published 21. Apr.] [W^m.]
- DE MAGALHÃES, PEDRO S.
- 1888.—*Notas helminthologicas* <Rev. brasil. de med., Rio de Jan., v. 1 (1) jan.-fev., pp. 5–20, 1 pl. [W^m.]
- 1895.—*Notes d'helminthologie brésilienne. (Quatrième note)* <Bull. Soc. zool. de France, Par., v. 20 (10), déc., pp. 241–244. [W^a.]
- MOLIN, RAFFAELE.
- 1858.—*Versuch einer Monographie der Filarien* <Sitzungsb. d. k. Akad. d. Wissensch., Wien, Math.-naturw. Cl., v. 28 (5), 11. Feb., pp. 365–461, pls. 1–2. [W^a.]
- 1860.—*Una monografia del genere Spiroptera.* [Read 15. Dec. 1859] <Sitzungsb. d. k. Akad. d. Wissensch., Wien, Math.-naturw. Cl. (1859), v. 38 (28), pp. 911–1005. [W^a.]
- 1860.—*Una monografia del genere Physaloptera.* [Read 9. Feb.] <Sitzungsb. d. k. Akad. d. Wissensch., Wien, Math.-naturw. Cl., v. 39 (5), pp. 637–672. [W^a.]
- [1861].—*Il sottordine degli acrofalli ordinato scientificamente secondo i risultati delle indagini anatomiche ed embriogeniche.* [Presented 14 gennaio] <Mem. r. Ist. di sc., lett. ed arti, Venezia (1860), v. 9, pp. 427–633, pls. 25–33. [W^a, W^a.]
- MÜHLING, PAUL.
- 1898.—*Die Helminthen-Fauna der Wirbeltiere Ostpreussens* <Arch. f. Naturg., Berl., 64. J., v. 1 (1), Mai, pp. 1–118, pls. 1–4, figs. 1–28. [MS. dated Dec. 1897.] [W^a.]
- NEUMANN, L. G.
- 1888.—*Traité des maladies parasitaires non microbiennes des animaux domestiques.* xv+673 pp., 306 figs. 8°. Paris. [W^a.]
- 1892.—*Idem.* 2. éd., xvi+767 pp., 364 figs. 8°. Paris. [W^a.]

- 1892.—A treatise on the parasites and parasitic diseases of the domesticated animals. Translated and edited by George Fleming. xxiii+800 pp., 364 figs. 8°. London. [W^a.]
- VON NORDMANN, ALEXANDER.
- 1832.—Mikrographische Beiträge zur Naturgeschichte der wirbellosen Thiere. 1. Heft, x+118 pp., 10 pls. 4°. Berlin. [Lib. Stiles.]
- PARONA, CORRADO.
- 1885.—Di alcuni elminti raccolti nel Sudan orientale da O. Beccari e P. Magretti <Ann. Mus. civ. di storia nat. di Genova, v. 22, 2. s., v. 2, 7 ottobre, pp. 424-445, pls. 6-7, figs. 1-25. [W^a.]
- 1889.—Intorno all' *Ascaris halicoris*, Owen, ed a qualche altro nematode raccolti in Assab dal Dott. V. Ragazzi <Ann. Mus. civ. di storia nat. di Genova, v. 27, 2. s., v. 7, 10 ottobre, pp. 751-764, figs. 1-5, pl. 13, figs. 1-16. [W^a.]
- 1889.—Sopra alcuni elminti di vertebrati birmani raccolti da Leonardo Fea <Ann. Mus. civ. di storia nat. di Genova, v. 27, 2. s., v. 7, 10-14 ottobre, pp. 765-780, pl. 3, figs. 1-18. [W^a.]
- 1894.—L' elmintologia italiana da' suoi primi tempi all' anno 1890. Storia sistematica, corologia e bibliografia <Atti r. Univ. di Genova (1894-95), v. 13, 733 pp., map. [Lib. Stiles.]
- RAILLIET, A.
- 1893.—Traité de zoologie médicale et agricole. 2. éd., fasc. 1, 736 pp., 494 figs. 8°. Paris. [W^a.]
- 1898.—Syngamose trachéo-bronchique de l'oie domestique <Compt. rend. Soc. de biol., Par., 10. s., v. 5 (13), 8 avril, pp. 400-402. [W^a, W^m.]
- RANSOM, BRAYTON HOWARD.
- 1904.—Manson's eye worm of chickens (*Oxyuris Mansonii*), with a general review of nematodes parasitic in the eyes of birds <Bull. 60, Bureau Animal Indust., U. S. Dept. Agric., Wash., pp. 1-54, figs. 1-40, pl. 1. [W^a.]
- RAYER, P.
- 1843.—Note additionnelle sur les vers observés dans l'œil ou dans l'orbite des animaux vertébrés <Arch. de méd. comp. (Rayer), Par., v. 1, pp. 113-154. [W^m.]
- RUDOLPHI, KARL ASMUND.
- 1819.—Entozoorum synopsis cui accedunt mantissa duplex et indices locupletissimi. x+811 pp., 3 pls. 8°. Berolini. [W^a.]
- SCHNEIDER, ANTON.
- 1866.—Monographie der Nematoden. viii+357 pp., 130 figs., 28 pls. 4^o. Berlin. [W^a.]
- SHIPLEY, ARTHUR E.
- 1903.—On a collection of parasites from the Soudan <Arch. de parasitol., Par., v. 6 (4), 1^{re} fév., pp. 604-612, pl. 7, figs. 1-9. [W^a.]
- SIEBOLD.
- 1837.—Zusatz zum vorhergehenden Aufsatz [Nathusius, Hermann, 1837, pp. 52-65] <Arch. f. Naturg., Berl., 4. J., v. 1, pp. 66-68. [W^a.]
- STOSSICH, MICHELE.
- 1897.—Filarie e spiroptere. Lavoro monografico. pp. 13-162. 8°. Trieste. [Lib. Stiles.]
- 1898.—Idem. < Boll. Soc. adriat. di sc. nat. in Trieste, v. 18, pp. 13-162. [W^a.]

STROSSICH, MICHAEL—Continued.

1899.—Strongylidæ. Lavoro monografico. [Reprint from Boll. Soc. adriat. di sc. nat. in Trieste, v. 19, pp. 55-152.] 98 pp. 8°. Trieste. [Lib. Stiles.]

1902.—Sopra alcuni nematodi della collezione elmintologica del Prof. Dott. Corrado Parona <Atti Soc. Ligust. d. sc. nat. e. geogr., Genova, v. 13 (2), giugno, pp. 61-76, pls. 3-5, figs. 1-38. [W^c.]

"C. W. W."

1891.—*Filaria oculi* in a parrot <Am. Vet. Rev., N. Y., v. 15 (5), Aug., p. 290. [W^a, W^m.]

WALTER, H.

1866.—Helminthologische Studien <7. Ber. . . . d. Offenbacher Ver. f. Naturk. (1865-66), pp. 51-79, pl. 1, figs. 1-6. [W^m.]

WESTRUMB, AUG. HENR. LUDOV.

1821.—De helminthibus acanthocephalis. Commentatio historico-anatomica adnexo recensu animalium, in Museo Vindobonensi circa helminthes dissectorum, et singularum specierum harum in illis repertarum. 2 p. l., 85 pp., 3 pls. fol. Hanoveræ. [Lib. Stiles.]

NOTES ON THE SPINY-SUCKERED TAPEWORMS OF CHICKENS

(*DAVAINEA ECHINOBOTHRIDA* (= *TÆNIA BOTRIOPLITES*) AND *D. TETRAGONA*).

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Authors generally have looked upon *Tænia botrioplites* Piana, 1881, a spiny-suckered tapeworm producing tubercle-like nodules in the intestines of chickens, as synonymous with the worm very incompletely described by Molin (1858, 1861) under the name of *Tænia tetragona*. *Tænia echinobothrida* Mégnin 1880 has also been considered by some (Stiles, 1896, p. 52) to belong to the same species, but more commonly (Blanchard, 1891t, pp. 433, 436; Railliet, 1893, pp. 306-307) recognized as distinct from *tetragona*, while *botrioplites* has been looked upon as a synonym of *tetragona*.

As will be shown in this paper my own observations have led me to conclusions in regard to these forms somewhat different from any yet presented. In view of the fact that one of the worms is responsible for a serious disease of chickens, while the other, with which it has been much confused in the past on account of its great similarity in structure, appears to be comparatively harmless, I believe a detailed discussion of my investigations, which seem to clear up a number of obscure points, will not be without value and interest.

GENERAL DISCUSSION AND HISTORICAL VIEW.

In connection with the present discussion a rather extensive consideration of the worms in question from the historical standpoint is necessary, and to this purpose I have quoted liberally from the comprehensive review given by Stiles (1896). That author (1896, p. 50) comments as follows on the original description of *Tænia tetragona* Molin, 1858:

Like most of Molin's descriptions, this diagnosis gives us but little information concerning the parasite he had before him. It should be noticed, however, that he (probably erroneously) describes the rostellum as unarmed, the neck as short (a character of little or no value), the posterior segments subquadrate and imbricate, the genital pores as unilateral, the length of the worm as 12 mm. to 90 mm., breadth as 2 mm. In other words, there is neither a single distinctive character nor a collection of characters given in this diagnosis. In his second paper (1861, pp. 254-255,

pl. 7, figs. 5-8) Molin repeats this diagnosis, gives four figures of the worm which are almost useless except fig. 7, in which the genital pores are figured in the middle of the lateral margin, and in which some irregularly shaped masses are drawn, which evidently represent egg capsules. He also adds three observations to the effect that he collected 42 specimens from one chicken, of which number only 2 were mature, the others being very small. He describes a mosaic structure of the segment caused by egg capsules, each of which contains from 5 to 20 ova. Although the rostellum is unarmed, the form differs in organization from the other unarmed forms. These are all the characters ever given by Molin to the species, and it must, indeed, be admitted that they are not sufficient to determine any worm with certainty. Molin's diagnosis, without the type specimens, is therefore useless.

In addition to what Stiles has given it may be noted that in Molin's fig. 7 the genital pore in one of the segments is shown at the middle of the lateral margin; in the other two slightly in front of the middle. It may also be stated here that a portion of Molin's original material, presented by the Vienna Museum to the Bureau of Animal Industry, is preserved in the Helminthological Collection of the latter, No. 1389. An examination of this material, however, so far as any positive results regarding *T. tetragona* were concerned, proved disappointing. Only a few small fragments were present, evidently representing some of the forty small specimens mentioned by Molin, and these were identical with *Hymenolepis carioca* (Magalhães, 1898). Neither of the two large worms of which Molin speaks and chiefly upon which he seems to have based his diagnosis was present. If still in existence they probably remain with the rest of the material in the Vienna Museum, and from these only may the identity of Molin's species be determined with absolute certainty.

Stiles (1896, p. 50) continues his discussion as follows:

As far as any original observations are concerned Molin's species *T. tetragona* then rested for a number of years. In 1880 Mégnin (1880, p. 119) mentioned *T. echinobothrida* * * *. In 1881 two parasites of chickens, very similar to if not identical with *T. tetragona*, were described as new. Mégnin described and figured *T. echinobothrida* as a new species with the characters given in the diagnosis above [Stiles, 1896, p. 49]. A careful study of both figures and description shows that the most important characters at present to be considered are the hooks upon the rostellum, said to be about 100 in number, $8\ \mu$ long, the rows of hooks upon the suckers (6-7 rows), those of the middle row being the largest; genital pores irregularly alternate; eggs $90\ \mu$ in diameter, spherical, arranged in groups of 6-7 in roundish egg capsules.

In March of the same year (1881) Piana (1882, pp. 387-391, 1 pl.) presented a paper before the *Accademia delle Scienze di Bologna*, in which he described as a new species *T. bothrioplitis* [*Tænia botrioplites* Piana, 1881, pp. 84-85], a cestode which he found causing serious damage to poultry, producing tubercles in the intestine. The chief zoological characters taken as a basis for the species are as follows:

Head, 0.35 mm. in diameter; retractile hemispherical rostellum armed with hooks (number not given, but evidently ca. 200, form shown in drawing); suckers with seven or eight concentric rows of hooks (form as per drawing), hooks not all of same size; neck very long, containing ovoid calcareous corpuscles; genital pores unilateral, situated somewhat below (distally) the middle of the lateral margin; cirrus short, pyriform; eggs in egg sacs.

* * * Piana was acquainted with Mégnin's paper, but separated his form from Mégnin's species chiefly on account of the form of the hooks on the suckers, the number of the hooks on the rostellum, and the arrangement of the genital pores. Krabbe (1882, pp. 361-362, pl. 2, figs. 55-60) published as *Tænia tetragona* Molin some cestodes which Fedschenko had found in chickens in Turkestan. He admits the total inadequacy of Molin's figures and descriptions, but determines his specimens as *T. tetragona* on account of the egg capsules. The characters given are as follows:

Length to 250 mm.; breadth, 1.6 mm.; posterior segments, 1.2 mm. long by 1.6 mm. broad. Head provided with a short and broad retractile rostellum, surrounded by about 200 hooks arranged in a double row; hooks measured $6\ \mu$ long from the apex of the prong to the end of the dorsal root; ventral root $11\ \mu$ long; suckers surrounded by several rows of * * * [variable unstable hooks similar to those of *T. australis*.] Genital pores unilateral; cirrus smooth, $21\ \mu$ long by $8\ \mu$ thick. Eggs arranged in egg sacs, 10-12 ova in a group, 40 to ca. 90 groups in a segment.

Since Krabbe's paper, authors have as a rule accepted *T. tetragona* as a good species. Blanchard (1891, pp. 433, 436) recognized *D. echinobothrida* as a distinct species; recognized *D. tetragona* (Molin) as valid, and made *T. bothrioplitis* a synonym of *D. tetragona*. Grassi & Rovelli (1892, p. 84) claim to have recognized both *T. tetragona* Molin and *T. bothrioplitis* Piana, and state that they have found both forms; *T. echinobothrida* Mégnin they did not find, but they think it is possibly identical with *T. bothrioplitis* Piana. Railliet (1893, pp. 306-307) has followed Blanchard (1891).

From the above it is questionable whether Molin's specific name *tetragona* can be retained unless the originals can be found and redescribed, for the description given by Molin is unrecognizable without the types. It might possibly be retained upon the ground that it is impossible to show that *T. tetragona* of present authors is not identical with *T. tetragona* Molin. I refrain temporarily from suppressing the name, as I hope the types may be reexamined. Krabbe's description of *T. tetragona* can hardly be taken into consideration in this question, as there is nothing to show that his specimens are identical with Molin's forms, and as Krabbe himself admits the uselessness of Molin's description and figures. The differences between the species described by these three authors (Mégnin, Piana, and Krabbe) are very slight and can for the most part be explained by contraction, insufficiency of material, and lack of details. The description of the hooks of the suckers of *T. echinobothrida* (as being so simple) should, I believe, be taken with reserve. The hooks are very small and not easily studied. The fact that the genital pores are described as irregularly alternate by Mégnin and unilateral by Piana and Krabbe is not, in my opinion, a serious difference in this genus. This opinion, radical as it may appear, is based upon the following observations:

The worms which Doctor Moore found producing a nodular disease in chickens give rise to the same pathological conditions as the form described by Piana, and agree with Piana's species in regard to the armed rostellum, the form and size of the hooks, both on the rostellum and suckers, and in almost every other character mentioned by Piana. The genital pores vary in different specimens. In some specimens they are entirely unilateral; in other specimens all but one or two may be on the same side of the worm, in fact it is often necessary to mount the entire strobila before it is possible to find an alternating pore; in still other specimens the pores are extremely irregular. The specimens with irregularly alternate genital pores agree in all other respects, so far as I can see, with Piana's form. The only difference between these specimens and Mégnin's description appears to be (1) the number of hooks upon the rostellum (Mégnin estimates them at about 100, the American form possesses ca. 200-208); (2) the form of the hooks on the suckers (in Mégnin's form the largest hooks are in the center row, in the American form the largest

hooks are those of the external row). This latter point of difference should not be given too much weight, as Mégnin evidently made no microtome sections, and this point could hardly be established definitely otherwise.

In short, I incline to the belief that *tetragona*, *echinobothrida*, and *bothrioplitis* all represent one and the same species.

I have had opportunity to examine a large amount of tapeworm material collected from chickens in various parts of the United States,

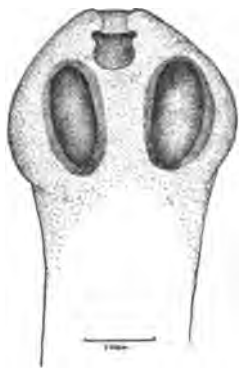


FIG. 41.—Head of *Davainea tetragona*. Enlarged. Original.



FIG. 42.—Head of *Davainea echinobothrida*. Enlarged. Original.

and so far have found five distinct species—*Hymenolepis carioca*, *Choanotænia infundibuliformis*, *Davainea cesticillus*, and two spiny-suckered forms. The last are fairly common and occasionally occur

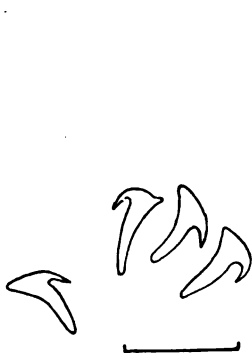


FIG. 43.—Hooks from the rostellum of *Davainea tetragona*. Enlarged. Original.

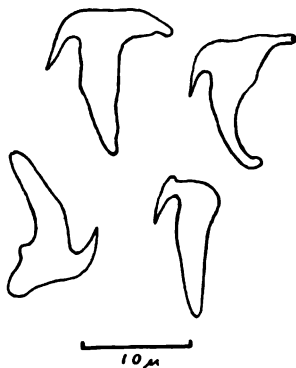


FIG. 44.—Hooks from the rostellum of *Davainea echinobothrida*. Enlarged. Original.

together in the same host. They are very similar to each other in size and general appearance, possessing, besides armed suckers, hooks on the rostellum, and numerous egg capsules. They show, however, certain distinct anatomical differences and, what is important, differ

very materially in their effects upon their hosts. One of them is the form found by Moore (1895) producing nodules in the intestines of chickens, and considered by Stiles (1896) identical with *T. botrioplites* Piana as well as with *T. echinobothrida* Mégnin and *T. tetragona* Molin of Krabbe. There can scarcely be any question as to the identity of this form with the European species *botrioplites*. Not only does it and the intestinal lesions produced by it agree perfectly with Piana's description, as Stiles has remarked, but it also agrees with specimens [B. A. I. Collection No. 1069] which I have examined of tapeworms collected from chickens in Genoa and identified by Parona as *T. botrioplites*. With these specimens is a piece of intestine showing the characteristic nodules. There is also perfect correspondence with the descriptions of the worms producing similar lesions found by Rátz (1898) and other European authors. This species is characterized in

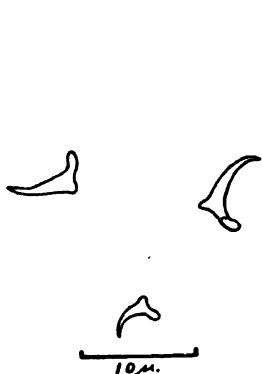


FIG. 45.—Hooks from the suckers of *Davainea tetragona*. Enlarged. Original.

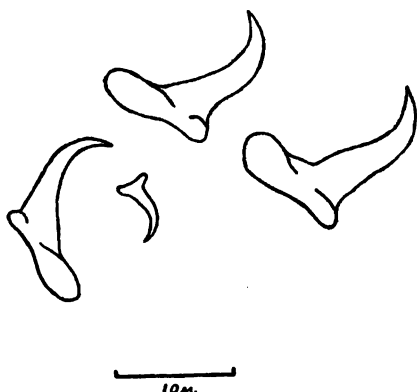


FIG. 46.—Hooks from the suckers of *Davainea echinobothrida*. Enlarged. Original.

part by the possession on the rostellum of a double row of about 200 hooks, 10 to 13 μ long (extreme length as measured in isolated hooks), and on the suckers a number of rows of hooks of variable size, the smallest 6 μ and the largest 12 to 15 μ in extreme length. The genital pores of this species, usually irregularly alternate, are situated behind the middle of the lateral margin of the segments, and the cirrus pouch is large, measuring 130 to 180 μ in length. In contracted specimens the neck is very thickset, and the head in general is exactly similar in appearance to Mégnin's figure of the head of *T. echinobothrida* (Mégnin, 1881, pl. 5, fig. 2).

The other species of spiny-suckered worm occurring in American chickens possesses a less conspicuous rostellum than the first form. It is armed with a single crown of about 100 hooks, which measure in extreme length 6 to 8 μ , and acetabular hooks 3 to 8 μ long. The genital pores are generally unilateral, and are situated in front of or

at the middle of the lateral margin of the segments. The cirrus pouch is small, measuring 75 to 100 μ in length. This species also shows an important difference from the other in that it does not seem to produce nodules in the intestine of its host, so far at least as my observations go. This is probably to be explained by the smaller size

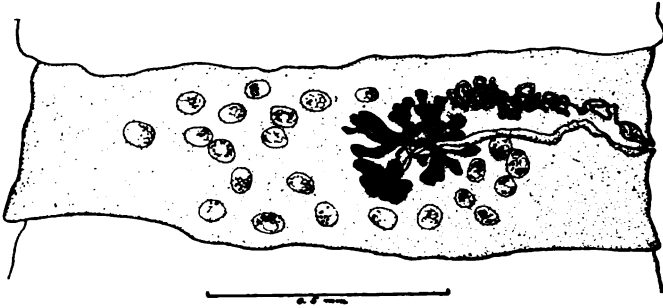


FIG. 47.—Segment of *Davainea tetragona* showing the reproductive organs. Enlarged. Original.

of the hooks. It may also be remarked here that nodules are not always to be found associated with the presence of the former species; cases are frequently seen in which the adult worms occur without apparent intestinal lesions. It is especially in association with the presence of young worms that nodules are found.

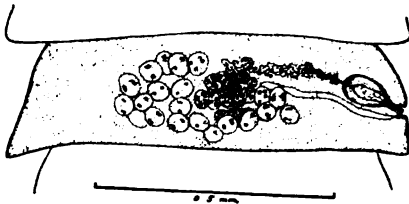


FIG. 48.—Segment of *Davainea echinobothrida* showing the reproductive organs. Enlarged. Original.

Although Mégnin's description of *T. echinobothrida* leaves much to be desired, I believe it is sufficiently distinct, all things considered and making allowances for possible errors of interpretation by Mégnin, to enable us to state with tolerable certainty that *T. echinobothrida* and *T. botrioplites* are one and

the same form. It further seems evident that Krabbe (1882) based his description of *T. tetragona* partly on specimens of *echinobothrida* and partly on specimens of the small-hooked form. The details concerning the head: 200 hooks arranged in a double row on the rostellum; the hooks 6 μ long from the apex of the prong to the end of the dorsal root; ventral root 11 μ long, certainly correspond more nearly to the former species, while the unilateral arrangement of the genital pores agrees more closely with the normal condition in the latter. Krabbe's drawings of segments also suggest the latter species in that the genital pore in both drawings is farther anterior than is normal in *echinobothrida*, and the cirrus pouch is much too small for *echinobothrida*, although, to judge from the scale of magnification given by Krabbe, slightly larger than is usual in the small-hooked species.

The extensive description and numerous figures, which Filippi (1892a, pp. 75-78, figs. 1-4; 1892c, pp. 249-294, pls. 1-10) gives of a chicken tapeworm identified by him as *Tænia bothrioplitis*, show very clearly that the specimens which he studied did not belong to the species named, but to the small-hooked species, *Davainea tetragona*. Returning now to Molin's description of *T. tetragona*, we have the following possibilities to consider in connection with the question of the identity of the worms studied by him: (1) Are they identical with *T. echinobothrida* Mégnin? (2) Are they identical with the small-hooked species mentioned in this paper? (3) Were specimens of both species present in Molin's material? (4) Were specimens of neither species under discussion but of a similar species present? (5) In addition to specimens of one or both of the forms under discussion, or of a

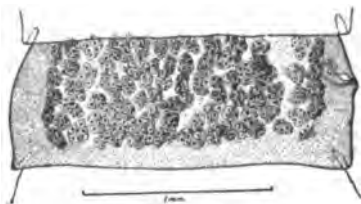


FIG. 49.—Gravid segment of *Davainea tetragona* Enlarged. Original.



FIG. 50.—Gravid segment of *Davainea echinobothrida*. Enlarged. Original.

similar species, were specimens of still other species present?

The last possibility has already been shown to be true by the fact that the original material upon which Molin based his species contained specimens of *Hymenolepis carioca*. It seems not im-

probable, moreover, that he actually based his description and drawing (1861, pl. 7, fig. 6) of the head of *T. tetragona* on specimens of *H. carioca*, in which the head is small, globose, and unarmed.^a

^a In a former paper (Ransom, 1902) I stated that in a head sectioned in situ with a piece of intestine the suckers were armed with small hooks. All other specimens of the head of *H. carioca* which I have seen showed no traces of hooks either on the suckers or on the rostellum. It was then my opinion that in the latter, hooks had probably been present at one time, but on account of their unstable nature had been lost. Further study has, however, since shown that the hooks seen upon the head in question are the same as those of the small-hooked tapeworm discussed in this paper. This one head, therefore, belonged to the small-hooked species of spiny-suckered tapeworm, and, consequently, so far as our present knowledge goes, the head of *H. carioca* is never armed. The only possible evidence to the contrary we now possess is the statement of Magalhães (1898, p. 450) that he believed he saw in one specimen what appeared to be little spines on the surface of the scolex near the inner posterior borders of the suckers. He was, however, doubtful on this point, and, moreover, found no trace of hooks on any other specimens examined.

Concerning the possibility, first, that the original *T. tetragona* is identical with *T. echinobothrida*, there is nothing to show absolutely, with our present knowledge, and without further examination of the type material, that such is not the case. Since, however, the genital pores are described as unilateral and since their position is indicated at or in front of the middle of the lateral margin in Molin's figure 7, the second possibility that Molin had before him specimens of the spiny-suckered worm, with small hooks, seems more probable.

With regard to the third possibility that specimens of both species were present in Molin's material, it may be said that in such case the small-hooked species should bear the name *tetragona*, since the other form was eliminated by Mégnin when he applied to it the name of *echinobothrida*.

The fourth possibility scarcely needs to be considered at present.



FIG. 51.—Cirrus sac of *Darainia tetragona*. Enlarged. Original.

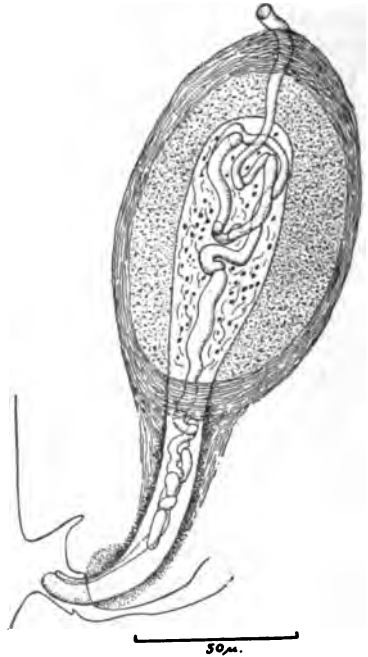


FIG. 52.—Cirrus sac of *Darainia echinobothrida*. Enlarged. Original.

So far as we know only two (unless *D. paraechinobothrida* Magalhães represent a third) species of tapeworm agreeing at all with Molin's diagnosis occur in chickens, and unless on examination of his type-specimens it is found that the original *tetragona* is different from either, one of them should be so designated.

Not only, then, does the small-hooked species correspond rather better than the large-hooked species to Molin's original diagnosis, but the latter, as already said, has been eliminated as *echinobothrida*, and so far as any present knowledge goes can not come into consideration. Until it be shown, therefore, on further examination of the type-specimens that *echinobothrida* is identical with the original *tetragona*, or

that neither of the forms under discussion is represented in the original material, we are not only fully justified in a provisional identification of the small-hooked form as *tetragona*, but in view of the apparent facts in the case we have left practically no alternative.

It may be noticed here that Magalhães (1898, pp. 442-443, 444) has mentioned a tapeworm of Brazilian chickens which he would identify with *Davainea echinobothrida* were it not for the fact that it possesses unilateral genital pores, but on that account he would separate it under the name *D. paraechinobothrida*. Whether in reality this form represents a distinct species, or whether it is identical with *D. tetragona*, or whether, perhaps, it should be considered only a variation of *echinobothrida* can only be decided when further details of its anatomy are known. The occurrence of *D. tetragona* in Brazilian chickens is established by specimens of this species in the Helminthological Collection of the Bureau of Animal Industry, No. 1388. These specimens, presented by the Vienna Museum, were labeled "*Tenia* sp. Intest. *Gallus gallinaceus* dom. Brasilien (Natterer)."

The specific characters of *D. tetragona* and *D. echinobothrida* are given in the following diagnoses:

SPECIFIC DIAGNOSES OF DAVAINEA TETRAGONA AND D. ECHINOBOTHRIDA.

DAVAINEA TETRAGONA (MOLIN, 1858) BLANCHARD, 1891.

(Figs. 41, 43, 45, 47, 49, 51.)

SYNONYMY AND BIBLIOGRAPHY

- 1858: *Tenia tetragona* MOLIN, 1858, p. 139 [a portion of the original material, B. A. I. No. 1389, consists of *Hymenolepis cariocca*].—IDEM, 1861, pp. 254-256, pl. 7, figs. 5-8.—POLONIO, 1860, p. 222.—DIESING, 1863b, p. 402.—KRAEBBE, 1869, p. 341.—IDEM, 1882, pp. 361-362, pl. 2, figs. 55-60 [in part].—PIANA, 1882, p. 393.—RAILLIET, 1886, p. 268.—IDEM, 1893, p. 306 [as synonym of *Davainea tetragona*].—NEUMANN, 1888, p. 429.—IDEM, 1892, [French ed.], p. 465.—IDEM, 1892 [Eng. ed.], p. 478.—GRASSI & ROVELLI, 1892a, pp. 84, 85.—DOLLEY, 1894a, p. 1017.—MOSLER & PEIPER, 1894, p. 40.—BRAUN, 1895b, pp. 194-195 [in part].—SCHNEIDEMÜHL, 1893, p. 290.—STILES, 1896, pp. 49, 50, 51-52 [as synonym of *Davainea tetragona*].—STOSSICH, 1895, p. 43 [as synonym of *Davainea tetragona*].—IDEM, 1898, p. 110 [as synonym of *D. tetragona*].—HOLZBERG, 1898a, pp. 154, 155-174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 185, 186, 187, pl. 10, figs. 2-7, pl. 11, figs. 15-22.
- 1891: *Davainea tetragona* BLANCHARD, 1891t, p. 436, fig. 15 [in part].—IDEM, 1899d, pp. 211, 215, 216, 217 [in part].—RAILLIET, 1893, pp. 305, 306 [in part].—MORELL, 1895, pp. 95, 99, 100.—STOSSICH, 1895, p. 43 [in part].—STILES, 1896, pp. 10, 12, 15, 46, 49, 50, C., pl. 17, figs. 219-227, pl. 18, figs. 228-235 [in part].—DIAMARE, 1898a, pp. 480-483.—STOSSICH, 1898, p. 110 [in part].—HOLZBERG, 1898a, p. 174.—LÜCHE, 1900, p. 92.—PARONA, C., 1901, p. 6.—GEDOELST, 1903a, p. 32.
- 1892: *Tenia botriophitis* FILIPPI, 1892a, pp. 75-78, pl. 1, figs. 1-4 [not *Tenia botriophitis* Piana, 1881].
- 1892: *Tenia botriophitis* FILIPPI, 1892c, pp. 249-294, pls. 1-10 [not *Tenia botriophitis* Piana, 1881].
- 1898: *Davainea tetragona* DIAMARE, 1898, pp. 480-483 [misprint for *Davainea tetragona*].
- 1898: *Davainea paraechinobothrida* [? synonym of *Davainea tetragona*] MAGALHÃES, 1898, pp. 443, 444.—BLANCHARD, 1899a, p. 217.
- 1901: *Tenia* (*Davainea*) *tetragona* VAULLEGEARD, 1901, p. 108.

SPECIFIC DIAGNOSIS.—*Davainea*: 10 to 250 mm. long by 1 to 4 mm. broad, these dimensions varying with age and state of contraction. Head (fig. 41) 175 to 350 μ in diameter, with retractile rostellum 50 to 70 μ in diameter, armed with a crown of about 100 hooks arranged in a single row. Suckers oval, 50 to 90 μ in diameter, armed with 8 to 10 rows of hooks. Rostellar hooks (fig. 43) 6 to 8 μ long through longest axis, hammer-shaped, with long ventral root and short dorsal root, prong

short and recurved. Acetabular hooks (fig. 45) of various sizes, from 3 to 8 μ , measured through longest axis, with long, thorn-like prong, dorsal root very short, ventral root longer than dorsal root, but shorter than prong. Neck usually long and slender. Segments (figs. 47, 49) trapezoidal and imbricate, edge of strobila serrate. Ultimate segments usually longer than broad, bell-shaped. Genital pores unilateral, situated at or in front of the middle of the lateral margin, frequently marked by a papilla. Male and female canals pass on the dorsal side of the nerve and excretory vessels.

Male genitalia (figs. 47, 51): Testes 20 to 30 in median field surrounding the female glands, most of them lying on the aporose side of the latter. Vas deferens lies in anterior third of segment, begins near the median line, and extends in a much convoluted course laterally to the base of the cirrus pouch, which it enters and after a few coils in the basal portion of the latter becomes transformed into the cirrus. Cirrus pouch (fig. 51) pyriform, 75 to 100 μ in length. Basal portion surrounded by a prominent layer of longitudinal muscular fibers, neck with a thick layer of transverse fibers. Cirrus without apparent spines.

Female genitalia (figs. 47, 49): Ovary in middle of segment. Yolk gland posterior of ovary, irregularly reniform, slightly longer in its transverse axis, about 100 μ in diameter. Shell gland prominent, 50 μ in diameter, immediately in front of yolk gland. Vagina begins at the genital pore posterior of opening of cirrus pouch, at first very slender, but at a distance of 15 to 25 μ swells out into a thin-walled tube, functioning as a seminal receptacle, which extends transversely across the segment and joins the oviduct on the dorsal side of the ovary near the median line. The oviduct after being joined in the shell gland by the vitelloduct proceeds forward and ends on the dorsal side of the ovary. A definite and persistent uterus is not developed. The eggs as they pass from the distal end of the oviduct become embedded in a fibrous and granular mass, which gradually fills up most of the segment. This mass divides into 50 to 100 portions to form egg capsules (fig. 49), each surrounded by a membrane and containing 6 to 12 or more eggs. The egg is surrounded by three envelopes, an inner, close to the onchosphere; a middle, folded; and a smooth outer envelope. The onchosphere measures 10 to 14 μ in diameter, the outer envelope from 25 to 50 μ .

LIFE HISTORY: Unknown.

HOST: Chickens.

PATHOLOGICAL EFFECTS: So far as known, very slight.

GEOGRAPHICAL DISTRIBUTION: Europe; Asia; North and South America.

DAVAINA ECHINOBOTHRIDA (MÉGNIN, 1880) BLANCHARD, 1891.

(Figs. 42, 44, 46, 48, 50, 52.)

SYNONYMY AND BIBLIOGRAPHY.

- 1880: *Tenia infundibuliformis* [in part] of MÉGNIN, 1880, pp. 395, 396.—IDEM, 1880, p. 716.—IDEM, 1881, pp. 125-126.—STILES, 1896, p. 49 [as synonym of *Davaina echinobothrida*].
- 1881: *Tenia echinobothrida* MÉGNIN, 1880, pp. 119, 120.—IDEM, 1881, pp. 35-38; pl. 5, figs. 1-11.—PIANA 1882, pp. 391-392.—RAILLIET, 1886, p. 267.—IDEM, 1893, p. 306 [as synonym of *Davaina echinobothrida*].—NEWMANN, 1888, p. 430.—IDEM, 1892 [French ed.], p. 466.—IDEM, 1892 [Eng. ed.], pp. 479-480.—GRASSI & ROVELLI, 1892a, pp. 84, 85 [as possible synonym of *Tenia botrioplites*].—DOLLEY, 1894a, p. 1014.—MORELL, 1895, p. 96.—STILES, 1896, pp. 49, 50, 51, 52 [as synonym of *Davaina echinobothrida*].
- 1881: *Tenia echinobothrida* MÉGNIN, 1881, p. 44 [misprint for *Tenia echinobothrida*].—PERRONCITO, 1886, p. 245 [misprint].
- 1881: *Tenia botrioplites* PIANA, 1881, pp. 84-85 [misprint for *Tenia botrioplites*].
- 1882: *Tenia botrioplites* PIANA, 1882, pp. 387-395, 1 pl.—PERRONCITO, 1882, p. 211.—IDEM [? 1901], p. 268.—STOSSICH, 1889, p. 30.—IDEM, 1891, p. 114.—PASQUALE, 1890, p. 909.—FILIPPI, 1892c, p. 250.—SCAGLIOSI, 1896, pp. 538-545, pl. 10, figs. 1-2.
- 1882: *Tenia tetragona* MOLIN of KRABBE, 1882, pp. 361-362, pl. 2, figs. 55-60 [in part].—BRAUN, 1895a, p. 194, 195 [in part].

- 1886: *Tenia bothriophyllis* RAILLIET, 1886, p. 267 [orthographic emendation of *botriophyllis*].—NEUMANN, 1888, pp. 429-430.—IDEM, 1892 [French ed.], p. 466.—IDEM, 1892 [Eng. ed.], p. 479.—GRASSI & ROVELLI, 1892a, pp. 84, 85, 89-90.—MOORE, 1895, pp. 2, 3.—MORELL, 1896, pp. 95, 96, 97, 98, 99, 100.—STILES, 1896, pp. 16, 49, 51, 52 [as synonym of *Davainea tetragona*].—STIEDA, 1900, p. 435.—PERRONCITO [? 1901], p. 268 [as synonym of *Tenia tetragona botriophyllis*].—HOLZBERG, 1898a, p. 154 [as synonym of *Tenia tetragona*].
- 1886: *Tenia botriophyllis* PERRONCITO, 1886, p. 245 [misprint for *Tenia botriophyllis*].
- 1891: *Davainea echinobothrida* BLANCHARD, 1891t, p. 433, fig. 9.—IDEM, 1899d, pp. 214, 216, 217.—RAILLIET, 1893, pp. 305, 306.—MOORE, 1895, p. 3.—STILES, 1896, pp. 10, 46, 49, 50, C., pl. 17, figs. 217-218.—MAGALHÃES, 1898, p. 442.—GEDORLST, 1903a, p. 32.
- 1891: *Davainea tetragona* BLANCHARD, 1891t, p. 436, fig. 15 [in part].—IDEM, 1899d, pp. 211, 215, 216, 217 [in part].—RAILLIET, 1893, pp. 305, 306 [in part].—MOORE, 1895, p. 3.—STOSICH, 1896, p. 43 [in part].—IDEM, 1898, p. 110 [in part].—STILES, 1896, pp. 10, 12, 15, 46, 49, 50, C., pl. 17, figs. 219-227; pl. 18, figs. 228-235 [in part].—RÄTZ, 1898, pp. 69-73, figs. 2-4.—IDEM, 1900, pp. 232-233.—MINGAZZINI, 1900, pp. 134, 151, 152, 154, fig. 10.—PERRONCITO [? 1901], p. 268 [as synonym of *Tenia tetragona botriophyllis*].
- 1891: *Tenia bothriophyllis* BLANCHARD, 1891t, p. 436 [orthographic emendation of *botriophyllis*; as synonym of *Davainea tetragona*].—IDEM, 1899d, p. 215 [as synonym of *Davainea tetragona*].—RAILLIET, 1893, p. 306 [as synonym of *Davainea tetragona*].—STOSICH, 1896, p. 43 [as synonym of *Davainea tetragona*].—IDEM, 1898, p. 110 [as synonym of *Davainea tetragona*].—STILES, 1896, pp. 49, 51 [as synonym of *Davainea tetragona*].
- 1894: *Tenia botriophyllis* DOLLEY, 1894a, p. 1013 [misprint for *Tenia botriophyllis*].
- 1896: [*Tenia*] *botriophyllis* SCAGLIOSI, 1896, p. 589 [misprint for *botriophyllis*].
- 1898: *Davainea bothriophyllis* MAGALHÃES, 1898, pp. 442, 443, 444.
- 1898: *Davainea paraechinobothrida* [? synonym of *Davainea echinobothrida*] MAGALHÃES, 1898, pp. 443, 444.—BLANCHARD, 1899d, p. 217.
- [1901]: *Tenia tetragona botriophyllis* PERRONCITO [? 1901], p. 268.

SPECIFIC DIAGNOSIS.—*Davainea*: Length to 250 μ ; width 1 to 4 mm. Head (fig. 42) 250 to 450, μ in diameter with retractile rostellum 100 to 150 μ in diameter, armed with a crown of about 200 hooks arranged in two ranks. Suckers round or oval, 80 to 200 μ in diameter, armed with 8 to 10 rows of hooks. Rostellar hooks (fig. 44) similar in type to those of *D. tetragona* but larger, measuring 10 to 13 μ in length. Acetabular hooks (fig. 46) likewise similar to those of *D. tetragona* but also larger, the largest measuring from 12 to 15 μ over all and the smallest 6 μ . Neck generally thicker and shorter than that of *D. tetragona*, frequently equal in width to the head. Strobila resembling that of *tetragona*, but with serrate border more pronounced. Ultimate segments in preserved specimens differ also from those of *tetragona*, being less elongate and frequently marked by a median constriction. Owing to this constriction the adjacent borders of the most posterior segments pull apart in the median line and remain joined only toward the sides, giving rise to a median series of openings through the posterior portion of the strobila. Genital pores irregularly alternate, or sometimes almost entirely unilateral, situated posterior of the middle of the lateral margin (figs. 48, 50). Male and female canals pass on the dorsal side of the nerve and excretory vessels.

Male genitalia (figs. 48, 52): Testes 20 to 30, arranged in median field as in *tetragona*. Vas deferens similar to that of *tetragona*. Cirrus pouch (fig. 52) flask-shaped, 130 to 180 μ in length. Basal portion globular or ovoid, surrounded by a thick layer (10 μ) of longitudinal muscle fibers, inside of which is a thick layer (15 to 20 μ) of transverse fibers. Neck of pouch measures 50 to 75 μ in length by 15 to 20 μ in diameter, surrounded by a layer of transverse fibers, thickened at the distal end of the pouch to form a sphincter. According to Ménézin the cirrus is armed with minute spines.

Female genitalia (figs. 48, 50): Female organs as in *D. tetragona*. Eggs similar in size and structure.

LIFE HISTORY: Unknown. According to Piana (1882) its supposed larva occurs in snails.

Host: Chickens.

PATHOLOGICAL EFFECTS: Produces a nodular disease of the small intestine.

GEOGRAPHICAL DISTRIBUTION: Europe; Asia; Africa (Pasquale, 1890); North and South America.

BIBLIOGRAPHY.

[The references may be consulted at the Governmental libraries in Washington, D. C., as designated: W*=Library of the United States Department of Agriculture. W=Library of Congress. W=Library of the Surgeon-General's Office. W=Library of the Smithsonian Institution.]

BLANCHARD, RAPHAËL.

1891 t.—Notices helminthologiques (deuxième série) <Mém. Soc. zool. de France, Par., v. 4 (3-4), pp. 420-489, figs. 1-38. [W*.]

1899 d.—Un cas inédit de *Davainea madagascariensis*; considérations sur le genre *Davainea* <Arch. de parasitol., Par., v. 2 (2), avril, pp. 200-217, figs. 1-3. [W*, Wm.]

BRAUN, MAX.

1895 b.—Die thierischen Parasiten des Menschen. Ein Handbuch für Studierende und Aerzte. 2. Aufl., 283 pp., 147 figs. 8°. Würzburg. [W*.]

DIAMARE, VINCENZO.

1898 d.—Ueber die weiblichen Geschlechtsteile der *Davainea* [sic] *tetragona* (Molin), eine kurze Antwort an Herrn Dr. Holzberg <Centralbl. f. Bakteriöl., Parasitenk. [etc.], Jena, 1. Abt., v. 24 (13), 12. Oct., pp. 480-483. [MS. dated 1. Juli.] [W*, Wm.]

DIESING, KARL MORITZ.

1863 b.—Revision der Cephalocotyleen. Abtheilung: Cyclocotyleen. [Presented 5. Nov.] <Sitzungsb. d. k. Akad. d. Wissensch., Wien, Math.-naturw. Cl., v. 49, 1. Abt. (4), pp. 357-430. [W*.]

DOLLEY, CHARLES SUMNER.

1894 a.—Synonymatic table of the animal parasites of man and of the animals commonly associated with him <Dict. Med. (Gould), Phila., pp. 978-1021, 60 figs. [W*.]

DE FILIPPI, CARLO.

1892 a.—Nota preliminare sul sistema riproduttore della *Tenia bothriophitis* Piana < Boll. Soc. rom. per gli stud. zool., Roma, v. 1 (1-2), pp. 75-79, pl. 1, figs. 1-4. [MS. dated 2 mar.] [W*, Wm.]

(1892 b).—Ricerche istologiche ed anatomiche sulla *Tenia bothriophitis* Piana. <Atti r. Accad. d. Lincei, Roma, Cl. di sc. fis., mat. e nat., v. 287, 4. s., v. 7, pp. 249-294, 10 pls.

1892 c.—Idem. Reprint. pp. 249-294, 10 pls. 4°. Roma. [Lib. Ward.]

GEDOELST, L.

1903 a.—Résumé du cours de parasitologie. ix+107 pp. 8°. Bruxelles. [Lib. Stiles.]

GRASSI, GIOVANNI BATTISTA; & ROVELLI, GIUSEPPE.

1892 a.—Ricerche embriologiche sui cestodi <Atti Accad. Gioenia di sc. nat. in Catania (1891-92), An. 68, 4. s., v. 4, 2. mem., 108 pp., 4 pls. [W*.]

HOLZBERG, KARL FRIEDRICH JOHANN LUDWIG BODO.

1898 a.—Der Geschlechtsapparat einiger Tänien aus der Gruppe *Davainea* Bl. <Zool. Jahrb., Jena, Abt. f. Anat., v. 11 (2), 26. Mai, pp. 153-192, pls. 10-11, figs. 1-33. [W*, W*.]

KRABBE, H.

1869.—Bidrag til Kundskab om fuglenes Bændelorme <Vidensk. Selsk. Skrift., Kjøbenh., Naturv. og math. Afd., 5. R., v. 8 (6), pp. 251-363, pls. 1-10, figs. 1-303. [W*, W*.]

1882.—Nye Bidrag til Kundskab om Fuglenes Bændelorme <Vidensk. Selsk. Skrift., Kjøbenh., Naturv. og math. Afd., 6. R., v. 1 (7), pp. 349-366, pls. 1-2, figs. 1-67. [W*, Wm.]

L'HE, MAX.

- 1900.—Untersuchungen über die Bothriocephaliden mit marginalen Genitalöffnungen <Ztschr. f. wissenschaft. Zool., Leipz., v. 68 (1), 14. Aug., pp. 43-112, pls. 4-7, figs. 1-31. [MS. dated Feb.] [W^a.]

DE MAGALHÃES, PEDRO S.

- 1898.—Deux nouveaux ténias de la poule domestique. (Notes d'helminthologie brésilienne. 8) <Arch. de parasitol., Par., v. 1 (3), juillet, pp. 442-451, figs. 1-12. [W^a., Wm.]

MÉGNIN, PIERRE.

- 1880.—De la caducité des crochets et du scolex lui-même chez les ténias. [Read 30 mars] <Bull. Soc. zool. de France, Par., v. 5 (1-2), jan.-mars, pp. 117-120. [Published 20 août.] [W^e.]
- 1880.—Sur la caducité des crochets et du scolex lui-même chez les *Tenias* <Compt. rend. Acad. d. sc., Par., v. 90 (12), 22 mars, pp. 715-717. [W^a.]
- 1880.—De la caducité des crochets et du scolex lui-même chez les ténias <Rec. de méd. vét., Par., v. 57, 6. s., v. 7 (8), 30 avril, pp. 393-396. [Discussion, pp. 396-397.] [W^m.]
- 1881.—De la caducité des crochets et du scolex lui-même chez les ténias <J. de l'anat. et physiol. [etc.], Par., v. 17 (1), 15 jan., pp. 27-44, 1 fig., pls. 4-5. [W^m.]
- 1881.—Sur la caducité des crochets et du scolex lui-même chez les *Tenias* <Compt. rend. Soc. de biol., Par. (1880), v. 32, 7. s., v. 2, mars, pp. 124-127. [W^m.]

MINGAZZINI, PRO.

- 1900.—Nuove ricerche sulle cisti degli elminti <Arch. de parasitol., Par., v. 3 (1), 15 mai, pp. 134-162, figs. 1-12. [W^a.]

MOLIN, RAPHAËLE.

- 1858.—Prospectus helminthum, quæ in prodromo faunæ helminthologicæ Venetiæ continentur <Sitzungsb. d. k. Akad. d. Wissensch., Wien, Math.-naturw. Cl., v. 30 (14), 20. Mai, pp. 127-158. [W^a.]
- 1861.—Prodromus faunæ helminthologicæ venetiæ adjectis disquisitionibus anatomicis et criticis <Denkschr. d. k. Akad. d. Wissensch., Wien, Math.-naturw. Cl., v. 19, 2. Abt., pp. 189-338, pls. 1-15. [W^a.]

MOORE, VERANUS A.

- 1895.—A nodular tæniasis in fowls <Circular No. 3, Bureau Animal Indust., U. S. Dept. Agric., Wash., 4 pp., figs. 1-2. [W^a.]

MORELL, ALEXANDER.

- 1895.—Anatomisch-histologische Studien an Vogeltünien <Arch. f. Naturg., Berl., 61. J., v. 1 (1), Mai, pp. 81-102, pl. 7, figs. 1-11. [MS. dated Nov. 1894.] [W^a, W^a.]

MOSLER, F.; & PEIPER, E.

- 1894.—Thierische Parasiten. xii+345 pp., 124 figs. 8°. Wien. (Nothnagel, Hermann. Spezielle Pathologie und Therapie, v. 6.) [W^m.]

NEUMANN, L. G.

- 1888.—Traité des maladies parasitaires non microbiennes des animaux domestiques. xv+673 pp., 306 figs. 8°. Paris. [W^a.]
- 1892.—Idem. 2. éd., xvi+767 pp., 364 figs. 8°. Paris. [W^a.]
- 1892.—A treatise on the parasites and parasitic diseases of the domesticated animals. Translated and edited by George Fleming. xxiii+800 pp., 364 figs. 8°. London. [W^a.]

PARONA, CORRADO.

- 1901.—Di alcuni cestodi brasiliani, raccolti dal Dott. Adolfo Lutz < Boll. Mus. di zool. [etc.], Genova (102), 12 pp. [Wm.]

PASQUALE, ALESSANDRO.

- 1890.—Le tenie dei polli di Massaua. (Descrizione di una nuova specie) < Gior. internaz. d. sc. med., Napoli, n. s., v. 12 (23), 15 dic., pp. 905-910, 1 pl., figs. 1-11. [MS. dated 5 settembre.] [Wm.]

PERRONCITO, EDOARDO.

- 1882.—I parassiti dell' uomo e degli animali utili. Delle più comuni malattie da essi prodotte, profilassi e cura relativa. xii+506 pp., 233 figs., 14 pls. 8°. Milano. [W*, Wm.]
- 1886.—Trattato teorico-pratico sulle malattie più comuni degli animali domestici dal punto di vista agricolo, commerciale ed igienico, metodi di cura ed appendice sui migliori metodi di disinfezione dei vagoni. xxiv+434 pp., 220 figs. 4 figs. by E. Semmer, p. 428. 8°. Torino. [W*]
- [?1901].—I parassiti dell' uomo e degli animali utili e le più comuni malattie da essi prodotte. Prolifassi [sic] e cura relativa. [2. ed.], xv+632 pp., 276 figs., 25 pls. 8°. Milano. [W*]

PIANA, GIAN PIETRO.

- 1881.—Una nuova specie di tenia delle galline (*Tenia* [sic] *botrioplites*) e di un nuovo cisticerco delle lumachelle terrestri (*Cysticercus botrioplites*). [Abstract of Piana, 1882] < Rendic. Accad. d. sc. d. Ist. di Bologna (1880-81), 17 mar., pp. 84-85. [W*]
- 1882.—Di una nuova specie di tenia del gallo domestico (*Tenia botrioplitis*) e di un nuovo cisticerco delle lumachelle terrestri (*Cysticercus botrioplitis*). [Read 17 mar. 1881] < Mem. Accad. d. sc. d. Ist. di Bologna, 4. s., v. 2, pp. 387-395, 1 pl., figs. 1-8. [W*]

POLONIO, ANTONIO FEDERICO.

- 1860.—Catalogo dei cefalocotilei italiani, e alcune osservazioni sul loro sviluppo < Atti Soc. ital. d. sc. nat., Milano (1859-60), v. 2, pp. 217-229, pl. 7, figs. 1-11. [W*]

RAILLIET, A.

- 1886.—Éléments de zoologie médicale et agricole. xv+1053 pp., 765 figs. 8°. Paris. [W*]
- 1893.—Traité de zoologie médicale e agricole. 2. éd., fasc. 1, 736 pp., 494 figs. 8°. Paris. [W*]

RANSOM, BRAYTON HOWARD.

- 1902.—On *Hymenolepis carioca* (Magalhães) and *H. megalops* (Nitzsch), with remarks on the classification of the group < Tr. Am. Micr. Soc., Lincoln, Nebr. (1901), v. 23, pp. 151-172, pls. 23-25, figs. 1-20. [Wm.]
- 1904.—Notes on the spiny-suckered tapeworms of chickens (*Darainaea echinobothrida* (= *Tenia botrioplites*) and *D. tetragona*) < Bull. 60, Bureau Animal Indust., U. S. Dept. Agric., Wash., pp. 55-69, figs. 41-52. [W*]

RÁTZ, ISTVÁN.

- 1898.—Parasitologiai jegyzetek. (Előleges közlemény) < Veterinarius, Budapest, v. 21 (3), 1 feb., pp. 65-75, figs. 1-5. [W*]
- 1900.—Wurmknötchen am Dünndarme < Ztschr. f. Fleisch- u. Milchhyg., Berl., v. 10 (11), Aug., pp. 230-233. [W*, Wm.]

SCAGLIOSI, G.

- 1896.—Ueber einen seltenen Ausgang der von der *Tenia botrioplitis* im Huhndarm herbeigeführten Verletzungen < Arch. f. path. Anat. [etc.], Berl., v. 145, 14. F., v. 5 (3), 17. Sept., pp. 538-545, pl. 10, figs. 1-2. [W*]

SCHNEIDEMÜHL, GEORG.

- 1896.—Lehrbuch der vergleichenden Pathologie und Therapie des Menschen und der Hausthiere für Thierärzte, Ärzte und Studierende. 2. Lief.: Die Vergiftungen. Die durch thierische Parasiten hervorgerufenen Krankheiten des Menschen und der Thiere. Die Konstitutionskrankheiten. Die Hautkrankheiten. pp. 209-448. 8°. Leipzig. [W^a.]

STIEDA, ALEXANDER.

- 1900.—Durchbohrung des Duodenums und des Pankreas durch eine Tänie <Centralbl. f. Bakteriolog., Parasitenk. [etc.], Jena, 1. Abt., v. 28 (14-15), 15. Oct., pp. 430-437. [W^a, W^m.]

STILES, CH. WARDELL.

- 1896.—Report upon the present knowledge of the tapeworms of poultry <Bull. No. 12, Bureau Animal Indust., U. S. Dept. Agric., Wash., pp. 1-79, pls. 1-21, figs. 1-276. [Published July 11.] [W^a.]

STOSSICH, MICHELE.

- 1889.—Brani di elmintologia tergestina. Serie sesta <Boll. Soc. adriat. di sc. nat. in Trieste, v. 11, pp. 23-30, pls. 13-14, figs. 55-61. [W^a.]

- 1891.—Elminti veneti raccolti dal Dr. Alessandro Conte de Ninni. Seconda serie. <Boll. Soc. adriat. di sc. nat. in Trieste, vol. 13 (1), pp. 109-116, pl. 1, figs. 1-6. [W^a.]

- 1895.—Notizie elmintologiche <Boll. Soc. adriat. di sc. nat. in Trieste, v. 16, pp. 33-46, pls. 4-6, figs. 1-37. [W^a.]

- 1898.—Saggio di una fauna elmintologica di Trieste e provincie contermini. [Reprint from Programma della civica scuola reale superiore published at the end of the scholastic year 1898.] 162 pp. 8°. Trieste. [Lib. Stiles.]

VAULLEGEARD, A.

- 1901.—Mécanisme de l'action des helminthes. [Review by Gallier] <Écho vét., Liège, v. 31 (3), mai, pp. 107-109. [W^a.]

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